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From the Shovel to the Buran Space Shuttle

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[Article by Andrey Tarasov under the "Science in the Modern World" rubric: "From the Shovel to the Buran Space Shuttle"]

[Text] When the Buran flew safely in, landed smoothly and taxied along the runway and stopped as though rooted to the ground, breathing the last of its fire, one of the shrewdest of the waiting experts and connoisseurs gave it what was obviously his highest compliment: "The pilot who handled the landing is apparently first-class: a non-drinker who's had a good night's sleep!" The ship probably enjoyed hearing this. Because the ship did all this and much more" by itself". To me, it even appeared to be laughing lightly on the final runway with a sort of dolphin-like smile.

But these days even a third-grader knows what is behind the words "by itself". A far-from-magic force includes the maneuvering engines which turn the elevon flaps and the rudder, which extends the landing gear and engages the braking system.

So it was that I have now found myself among the camp of the adherents of space automation. And not merely among the adherents, but with one of the convinced creators, whose rocket biography began long before the first satellite.

Throw a sack over my head, stop up my ears and order me to start walking around Moscow. No, the sack is not to conceal secrets, but to make a comparison. In utter sightless darkness, with no reference points, sounds or prompting, I have to walk down the blocks, along the streets, across the pedestrian "zebra" crosswalks, through the underground crosswalks, along footways and through gates. Then I must pass a precisely assigned time period to a precisely assigned place. I have to obey the stop and go lights and not fall beneath the wheels of the Icaruses or trolley cars, avoid falling into pits and ditches and bumping heads with other people.... And characteristically, I have never set eyes on this route.

This is approximately what a rocket flight is like. Not counting, of course, the velocity and lightning-like maneuvering speed. It can't see, hear or understand; it just travels according to a program, guided by its own inner voice. All the rest, as you yourselves understand, is a trifle: drawing up this program and making the rocket follow it unswervingly. And giving it, for example, a designation such as "autonomous inertial guidance system".

Vladimir Lavrentyevich Lapygin, who is a general designer of automatic control systems and director of a scientific production association which develops them, a Hero of Socialist Labor, winner of the Lenin Prize and the USSR State Prize and USSR people's deputy, immediately hits the nail on the head when he asks, "Do you know the primary difference between rocket technology and aviation? It is this: in aviation, control of the craft is always the responsibility of man. Automatics have gradually been increasing, but the crew has been the main character. A rocket, as we know, flies without a pilot. From the very beginning, only the on-board equipment has had to compute all the flight situations, measure deviations from the trajectory and corrections and provide accurate navigation. In a word, it has to solve a mass of problems and control the flight. This is why rocketeers have suddenly been faced with a post not found in aviation—that of chief control systems designer.

The chief designer, one of six chief designers who created Soviet rocket technology under the leadership of S. P. Korolev, was future academician and two-time Hero of Socialist Labor Nikolay Elekseyevich Pilyugin. And now the scientific production association is referred to as the "Pilyugin Firm".

As an engineer-aviator who spent the entire war devising highly precise airplane instrumentation, he was sent to Germany in 1945 in the same group which included Korolev. Their mission: to examine the V-2 rocket systems, primarily the capabilities of flying accurately (conditional for these models) to a target without external prompting. The future chief designers investigated the top secret Nordhausen cave, processed the seized technical documentation and became increasingly aware of the bitter struggle developing among the great opposing powers to possess this weapon.

And on the contrary, as luck would essentially have it, this technology was capable of serving as the right arm of the unity of the earth-dwellers before the face of the universe. More accurately, this is not luck, but conformity to law. The tractor and the tank, nuclear energy, rockets and satellites are the two heads of industrial power, and can be both a dragon and a dove. This is the real confrontation, and is more fatal for humanity than a face-off of armies. How can it be resolved?

I think that by itself, the safety valve of peaceful space has also given us a spirit of optimism. It was not as gloomy as "being zealous for the deadly bomb", and emerged as the real positive sense behind all the most refined technical solutions.

In each one of these firms it is the old-timers and veterans who in the course of time unintentionally became the chroniclers, and who leave a special impression. An account told by designer Georgii Moiseyevich Priss turned out to be useful. Of all those I spoke with, he is the "Pilyugin's" length of service champion—having worked since 1948. From this account, one can picture clearly with what an accessible simplicity its founders and leading lights took up this universal matter.

N. A. Pilyugin and his department of autonomous control systems was, for the first five years, a man who was attached to the production base—the experimental telephone equipment plant—where they were still making the famous TAI-43 telephone, the "induction telephone". The

ones you turned the handle on and cried out in a loud voice, " 'Roshcha!'—'Roshcha'!—This is 'Dub'! Add the little cucumbers!" It could be said that the bases and principles of self-controlled rockets began with this dry cell telephone.

The R-1 was the first rocket. It was similar to the V-series rockets. The first burn-through tests were held in autumn of 1948, and were a "real circus". Alongside a dacha settlement they had enclosed a woodsy area with iron bands and had brought out a mobile complex on wheels near the armored cars and motor vehicles. The public roamed along the paths among the pine trees gathering mushrooms and listening to the blazing roar. To the point, a fiery episode occurred there which was later recorded in the film "Taming the Fire", when Kirill Lavrov rushed to the installation with a water-cannon....

"And in February of 1949, they burned down our design office and plant....They forgot to shut off a soldering iron and a one-story building burned—the roof was insulated with peat crumb and prepared roofing paper....Morning came at the scene of the fire. The miracle in the first department's three-story office was that the documents were preserved. The entire design office was moved into the mess-hall..." That is how an administrative firm, the like which had never been in the Soviet Union, was born.

The R-2 rocket doubled the features of the V-series rockets by flying 600 km. Later on in 1953, having grown, the rocket design offices began making the preliminary drawings for the "7". Yes, the same world-famous rocket now operating in space.

At the time, Vladimir Lavrentyevich Lapygin did not think he would become the general designer and director of a firm. Good Lord!, only ten years ago he had been a medical student in an aviation plant in Moscow. As a young boy, he had run away from his home village in the Tula Oblast. The war began, October 1941, on the background of the bitterly-remembered "day of panic"—when they were still manufacturing Migs and Ilyushins...."They were still digging tank traps on the Novodevichiy Monastary grounds....Then the plant was rebuilt after the evacuation...After the war, he had his eighth birthday, then through the training courses—and into the MAI [Moscow Aviation Institute imeni Sergo Ordzhonikidze]." And with that very diploma he joined the firm in 1952. His scientific theme dealt with the subject of gyroscopes, pendulum sensitive elements and the high-precision electromechanics of the rocket-mounted "ante-chamber" [vestibyulyarka].

Gradually, the inertial guidance complex was developed, and the idea of using floating gyroscopes was conceived...We put our own measurement conversion heads on the "7" in the gyrovertical and gyro horizon, and they have been flying since 1957.

Does this give the impression that we took them off and put them on immediately?

"No, there were a great many failures, and a lot of rockets were destroyed....We got to be close friends with Sergey Pavlovich here. I came to Tyura-Tam for the first time in 1957. Railroad cars, barracks, pigeoncotes for people. I remember launching our first '7' in May. It was the fifth of the series. One of the side fins fell off 10 seconds prior to launch and there was an accident. We set up the sixth rocket and a valve froze during the start-up. It didn't fly anywhere. The seventh was rained on by a cloudburst in June. Where? In Tyura-Tam, in the desert! The insulation was drenched and the resistance fell to zero. We took it back to the technical facility, dried it out and launched it anyway. It followed the trajectory. The lateral units were joined to the center by electrical connectors. The pins were soaked with water which created a false circuit and turned the rocket in the wrong direction. Instead of landing in Kamchatka, it crashed six km away. Anyway, number eight got there. But I was no longer part of the effort. My boots were falling apart and my jacket was coming to pieces so the chief sent me to Moscow to calculate the results."

These crude elements conflicted with the extremely accurate course and acceleration measurers. There is a hymn written by the people at the test range. It is sung with enviable optimism:

The smoking rocket falling, And the crew fleeing from it—He who has seen this but once gives the rocket a thumbs up.

However, there is much more involved here than a simple thumbs up.

It is all right if the rocket carries only a measuring head; let it. God forbid it should be carrying some death-dealing load; it makes me tremble and pray for mercy just to think of it. But if a live person rides up in an elevator to the rocket nose after all these fires and wrong turns and sits down in it and says "Let's go!" in a voice ringing with emotion...I don't know what sort of nerves it takes to stand this. Maybe this is why chief systems and instruments designers turn grey so quickly and die prematurely under the leadership of their own chief, who is so full of celestial ideas.

But no matter how intense, it only takes ten minutes for a rocket to attain orbit. Even though these launches can bring about their own technical revolutions. "For example, a launch without a rotating launch pad. The launch marshallers have refused to believe three written reports each and have demanded that the rocket must travel to its destination from a vertical position. If we do not aim it, but trust in a tiny mechanism on board, which aims in flight...."

An altogether different problem concerns interplanetary automatic controls. Here, as in any area of risk, there have been both tremendous successes and disappointing failures. On more than one occasion, when observing a gathering of chief designers in the TsUP [Flight Control Center] or the space launch facility I attempted to read their stony faces during the complex operation. What are

they thinking; what are they feeling? Here, Vladimir Lavrentyevich helped me greatly.

"For me, the launch and stage separations and the ignition of the final stage engine were the most unnerving. I recall the panoramic television view of the moon....We had some failures getting there, too, and we lost some rockets. That was still under the leadership of Sergey Pavlovich (Korolev). For example, the Ye unit simply means the sixth letter in the alphabet, or a lunar landing unit. In addition to the inertial guidance system, we were already using astronavigation there. You have to keep both the earth and the moon in sight. So we set the unit control for 10,000 km. We flew the rocket, we slowed it down, and then we switched off the engine and began free fall to the moon...One device twisted and fell off—a shock-absorbing bag was punctured....The Getinaks plastic insulator had not been glued on according to instructions and didn't have enough stability....Then we flew on an AN-12, first to Baykonur for the launch and then to Simferopol for control...Six people in the cabin. And then, before the landing on the moon, this was our first flight without Korolev. We were all feeling gloomy; we took walks, we worried. Keldysh Mstislav Vsevolodovich comforted us by saying everything would be all right. And you transmit television pictures of geological sills! Finally we had done everything and we heard the beep-beep of the telemetry signals. We wrote to TASS. And in our joy we somehow forgot about the television transmissions. What is it transmitting? We look and there is nothing but snow on the screen! It turns out that it didn't switch on. In our reports, we began skirting this issue, as if the television didn't exist. Then the picture was dark and looked like piles of cobblestones. But Keldysh once again took heart: But what did we want to see on the moon? Palaces and women? Imagine that the sills are in Tyura-Tam. And what did it look like? The desert!" We began to tune in the receiver and the reception got better with every picture. We sent a photo to Moscow. But we were still afraid to tell the whole world. We wanted to make better and better photographs."

"Even now I can recall how these pictures of the lunar panorama roused us all. How much more peaceful they look than even the pictures of Phobos, which were far more difficult to obtain."

Yes, Phobos-1 and Phobos-2....As we were talking, behind my back there was a large classroom blackboard marked all over with chalk. Diagrams, formulae, strings of signals. The last command and the last response.

This is exactly how the loss of the second Phobos spacecraft is being investigated in many institutes and design offices. Finding the reasons behind it is far from simple. But knowledge of these cases is a better medicine for the future.

All the same, let us get back to the successes, which include the Buran, which has still not cooled down.

And let us get back to the trip through Moscow, from Moscow State University to the Ostankinskiy Television Tower, for example. Only this time we have to get there not merely in one piece and on time, but we have to perform a number of tasks. Send a telegram along the way, buy some produce and vegetables, make a call at a public telephone, have a snack at a cafe, pay the apartment rent, repair a watch....

This will represent the flight of the Buran compared to a rocket flight. The number of maneuvers and manipulations performed by the crew from launch to landing is beyond counting. From the course selection, orientation and stabilization to the interaction of a host of internal systems and assemblies.

However, both yes and no. In the permanent version, this is no longer a completely blind and deaf flight, but has the prompting of celestial orientation. The landing itself is guided by radio beacons, but at an altitude of 40 km. Until then, including the hottest flaming leg of the flight, we are travelling "by our own mind".

The world of details in this unique system immerses us in the abyss of outer space. It is one of those technical devices which are made up of highly sensitive instruments and transducers. But somewhere there is that "nail", upon which everything hangs.

The system is being devised, by and large, by the preeminent experts in this field. Avenir Sergeyevich Vykov controls the basis of the inertial measuring complex—the gyro unit. This unit is the fruit of two decades of cerebral scientific and design effort. At the end of the 1950's the unit weighed three kgs, and permitted deviations of 5 angular degrees per hour from the assigned axis.

"Is that a lot?"

"Quite a lot! This requires continuous corrections. But now the corrections are within tolerances: using the on-board computing complex, they come to a thousandth of an angular degree per hour."

And in appearance it is a rather small rounded two-hundred-gram container. Inside, there are 2,500 items. There are gas bearings, fluid jackets, precise machining, ion spraying, micronic clearances....Like the little matryoshka dolls, there is jacket after jacket. We take them apart until we get to the main jacket. Here it is! A tiny 20-gram "top", the rotor gyromotor! And it is these 20 little grams that keep the hundred-ton Buran on course, performing forward flips in weightless space and zigzags in the atmosphere. The "top", which spins with terrific force, constantly maintains its own axis relative to selected coordinates of the universe. And it is as though the ship turns around it. And it remained to highly delicate measuring devices to keep track of this turning: now it has underturned, and now it has overspun. And to give commands to the rudders.

Now all the remaining equipment can be hung on this "tack". The gyroscope is not all-powerful. It does not sense lateral drift. It also needs a helper, and an accelerometer alongside to back it up, for which reason the gyrostablized plaform has been developed. Now it is a 25-kg unit with a circular black cover, and can be held in one's hands. It is a trihedral version (with three standbys). The monohedral version used to weigh 50 kg. And here we have three such platforms, again with redundancy, held fast by a single unit behind the bulkhead of the pilot cabin in the freight hold.

And this is where we start hearing "but what if?". So we check them "staying close to the till", i.e., close to the test stand.

But even so, gyroscopes vary from their base settings, if only a little after a time. They have to be adjusted every 15 hours. And this is where the celestial transducers come into the picture. Here they are: little white telescopes revolving on their heads, looking into black boxes which simulate the starry sky. Just so, they will quiver lightly during the flight, after having homed in on the reference star. The star has been programmed into the computer, where it is identified by a map programmed into the computer memory, with the requisite data selected to refine the information and the proper command sent to the gyroscopes.

Well what if we suddenly get turned around in space and utterly confuse the gyroscope? Anything can happen-....The ship has turned upside down and has risen, even if only a little, to lock on the earth and to find its lost orientation. This is the sequence of the plotter for local vertical, which is mounted on the same platform. Huge, divided into partitions and looking like an electric grill, the earth simulator uses its thermal radiation to attract the infrared receiver. Then the search, the thermal lock-on, the processing of the signals, the earth and stars involved in a computer "conference", calculating the ship's area and position....

But now everything that can break down has done so—the gyroscopes (with their 9-fold redundancy) and the PMB [possibly turret traversing mechanism]. Now the crew's hope lies in its ability to handle the VDK—the video-range finder (cosmonaut). The white tube above the pilot's head, trapping the stars swimming by into the crosshairs, pressing the button for the horizontal and vertical, once again the computer "confers", compares this data to the starmap, and plots the ship's position relative to it. And in case of a total failure, we have the NIVS—the visual navigation-measurement system for independent star identification. The viewfinder, which can "move" independently of the ship, solving the problem along with the computer....

All this in addition to the number of "curves" and the type of memory and high-speed response built into the main on-board computer. And it is the same size (I compared it and was exposed to the irony of the experts) as a tractor battery. True, there are four of them on board—redundancy is mandatory. "The Americans don't understand how we Russians control four machines without failing. They have an on-board equipment set of five cabinets...." As for high-speed response: it takes the stationary computers of the earth-based complex (many large cabinets) two days to compute the forty-minute descent. And that is how much we have to prolong the shift of the testers modelling the flight. In fact, there are not just one or two descents, but dozens and hundreds before the computer is filled with the necessary algorithms. "And then, when everything is ready, the engine operators suddenly insert a change into the operation of the ODU [combined engine installation]. The machine has to readjust the program not only in order to control the engines, but to correlate them with all the ship's systems—and there are 52 of them! Some 48 hours of rush work begins...and must be done in 24 hours."

The computer on the flight stand is modestly lost among all the other electronic black boxes connected by a multitude of cables. Generally speaking, the control system consists of 1,100 highly complex electromechanical instruments with a total mass of roughly three tons. Three tons of a 100-ton ship. But in addition, the cabin light refuses to come on and the brakes don't work. The relays, the amplifiers, the converters, the filters...."We have sent the signal through the entire circuit more than once, from stem to stern—and that's the entire control apparatus," the control engineers grin.

That's what the minute sensitive little element we started with has become overgrown with. This is the "little tack" upon which all this hangs. The special feature and pride of the firm is that all these instruments are being designed and built right here "from ore to product". The firm is using its own science and its own production facility. Including its own computer, which is now on the flight stand being loaded with programs for the new flight. The on-board computer complex with the BTsVM [digital computer block] was developed by first class electronics specialists headed by Deputy General Designer Viktor Andreyevich Nemtsev and Department Chief Vycheslav Ivanovich Sorokin.

"This machine does not understand that it is on the earth. It flies in the proper way...."

Uriy Vadimovich Trunov and Viktor Sergeyevich Lebedev are heads of the departments where the algorithms for conceivable and inconceivable navigation and dynamic tasks are developed. In fact they "ordered" the designers to come up with a quadriframe gyroscope platform to replace the previous triframe setup so that the ship could perform unrestricted turns during maneuvers.

The main difficulty was this ship's unpredictable aerodynamics. Beneath the thick layers of the atmosphere, as it was graphically explained to me, the ship is like a car driven at a high speed onto a glaze of ice: the reaction on the steering wheel can be most unexpected. If you turn it

to the left, the car goes to the right and vice versa. You skid, slide and zigzag. These things cannot be avoided; you have to react flexibly and as quick as lightning to the gyroscopes' signals, accelerometers, and angular transducers. In this situation, the computer can send 30 commands per second to the rudder. And 38 small-thrust nozzles "play" their symphony, maintaining the ship's stability and direction. The main question—"Where are we?"—a navigation problem—is solved 16 times per second. The set of most challenging situations from which the ship finds its way out with the help of algorithms so far surpasses reality that the developers refer to it as a "horror film"

And the following question involuntarily comes up: "And the human? Is he up to this problem?"

"Of course not!". The controllers have no doubt about this. In this situation, the automatic controls are peerless. A human can cope with aircraft flight, when the approach to the runway is clear. This is why reliability is the most important thing. This has been our primary concern ever since the days of Gagarin.

The mathematical leap to the Buran is that all the preceding problems have been intermixed in 30,000 commands. Here there are 144,000, and the computer does not have enough on-line memory. It is helped by an external memory—a magnetophone—whose film is exchanged with the computer programmed information: new information is put in and old information is removed.

Who was most alarmed at this moment? "I was—during the separation from the Energiya. There, the turning program was right on target, God forbid it should err, and we brushed the rocket! It turned out all right: no mistakes were made and it is now in orbit!"

"As for me—when the pause in the plasma dragged on, and there were still no signals...My heart ached: then they began pouring out in bits and pieces....Angle of attack algorithms are crucially important to temperature conditions and for the limits of the heat shield tiles. If they err in one direction, the bow would melt and if in the other—the stern would burn up. But the ship came through in one piece, with one trifling error of two km in altitude, and 600 m to the side...." "We have a bearded fellow near our control panels who did not dismantle the internal television system from the ship's cabin after the plasma; at first, nothing was visible. 'Everything is falling, falling!' He fell to his knees in confusion."

To the point, we get questions in the mail. Here, S. Chugunov from Lithuania asks why the ship touched down on the runway unevenly; the right wheel and then the other wheel?

"And this is precisely as called for in the program for landing in a strong lateral wind. That's is how a first-class flyer would land...."

I ask the general designer who carried out the landing in the command bunker at the spaceport:

"Vladimir Lavrentyevich, what are your main pre-flight parting words to your specialists?"

"My main parting words? I tell them not to mix up the polarity. The most typical careless act is to mix up their polarities. And I constantly tell them not to burn up because of polarities...."

Of course, there is a massive three-day program of polarity checks for this, when the control system in the check-and-test station at the spaceport slaps all the shuttle's valves shut and moves all the flaps. And deep within the shuttle there are no more or less than 350,000 ERE's [electroradioelements]. There are many millions of soldered joints.

Behind each soldered joint are the hands of the installer. Behind each part is the manufacturing process which is, perhaps, the high point of our technological culture. The shop which deals with the sensitive elements—gyrostabilizer heads and accelerometers—allows one part of dust per liter of air. The second frequency class is up to 350 and the first frequency class is no more than 30 parts. The dust motes are up to 8 microns in size. And in the assembly "tents", or clean boxes, there is generally zero dust; they are air tight equipped with filters. Workers are required to wear special cambric coveralls and wash their hands in formalene. "We noted that a batch of parts had rusted. What had caused this? We began determining the causes and it turned out that there was acid in an assembler's perspiration, and it had corroded the parts...."

The assembly and control shops for the gyroplatforms and installing the circuits have an operational perception which is common to the space industry. The surgical robes and gloves, the precise unhurried "clever" hands, the concentrated intelligent faces....Every operation has its own acknowledged aces. Installer Zinaida Mikhaylovna Bakhtina, assembler Viktor Ivanovich Panferov, adjuster Vladimir Fadorovich Lugovskikh....

I used to think that these production operations were performed only in an ideal climate, in a virgin pine forest. "And it used to be that way, during construction—solid woods all around. Now we're surrounded by the city, main lines, construction projects, dust, noise...."

And this industry itself, with its precision and categories of reliability seems like the beachhead of a more developed civilization. Things are difficult for it right now—the budget shakedown has already affected orders and workplaces.

We call this a planned economy, but there are no plans. The financing has been cut off without any preparation or transition and the enterprise has received neither money nor contracts for the quarter....We have produced output in accordance with the program for joint operations, but the client cannot pay for them. Tomorrow they

will put us in jail for taxes and the day after tomorrow our labor forces will scatter. The problem is, these people have been together for decades, and are priceless. But the average wage for one of our programmers is R175 per month, where a cooperative pays R500-600. We are developing equipment which operates through one, two or three failures, and can it be that no one needs it? The fact is that nuclear power stations, the chemical industry, the mines and our ecological systems need this level of reliability. We are stopping special-purpose production and developments; they will always be difficult to recover, and they will be wrecked forever!

Once again we have the problem of the blind fence between the space industry and all other industry. Actually, using an axe to make savings in the budget in this sensitive field is fraught not only with the loss of priorities, but with a lowering of our record-breaking production plan.

True, plant director Feliks Aleksandrovich Lomako has a more optimistic frame of mind. He is totally involved in finding out whether the plant has the experience needed to manufacture medical equipment.

"If allocations for space-rocket equipment are cut, the plant could change over to manufacturing equipment for the oil, gas and medical industries. We are going to make cuvettes [kyuvezy] for new-born infants—some 650,000 of them are needed around the Soviet Union! And their requirements for sterility are no lower than for a gyroplatform. The air supply, temperature, oxygen, humidity, heating, monitor—it's like a thousand and one nights! We will develop consumer goods and toys the like which have never been seen. I am going to ask only one thing—that we maintain our existing formal acceptance."

"And do those who are going to pay them for the toys also have khozraschet?"

"I'll pay them myself! Just so they don't lower the level of quality."

But we have finally finished our circle around the Buran with Vladimir Lavrentyevich Lapygin. How does he feel about the criticism levelled at him? Do we need the Buran or not?

With passion, the general designer asks, "Is the Buran causing farmers who slog through the snow and mud to lose 40 percent of their crop? What is causing poverty, if not our space program? I agree that so far little thought has been given to practical uses for the Buran. So far, we have put all our energy into developing it. But the country has to maintain its level and skills in the modern world!"

I perceive the country as a worker who has to have a complete set of the tools needed to construct a world fit to live in. Everything is created these days by the human intellect. From the shovel to the Buran.

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Nuclear Power Generation and Environment

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[Article by T. Kh. Margulova, doctor of technical sciences, Moscow Power Generation Institute, under the "Nuclear Power Plants" rubric: "Nuclear Power Generation and Environment"]

[Text] Twenty-six countries throughout the world—England, Argentina, Belgium, Bulgaria, Brazil, Hungary, the GDR, Holland, India, Spain, Italy, Canada, Pakistan, the USSR, the United States, Taiwan, Finland, France, the FRG, the CSSR, Switzerland, Sweden, the United Arab Republic, Yugoslavia, South Korea, and Japan—currently have operational nuclear power plants.

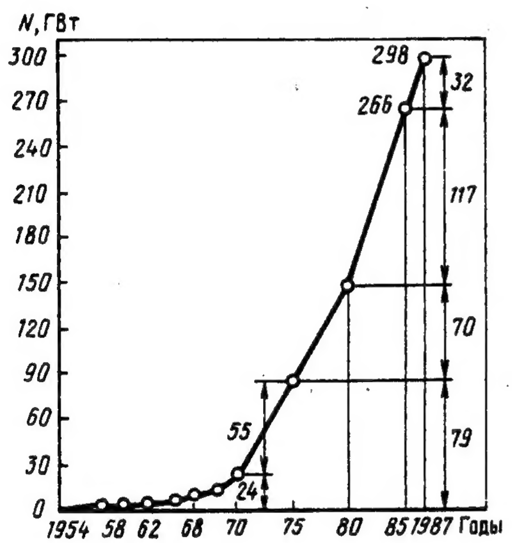

Figure 1. Total Power Produced (in GW) by Year

The United States has the AES with the largest aggregate capacity and is followed by France, the USSR, and Japan. France has the greatest percentage of electric power produced at an AES (about 80 percent of its total). Figure 1 shows the development of the total capacity of AES throughout the world. It is evident from this figure that, beginning in 1970, it has undergone intensive growth. The following average yearly increases in the total capacity of AES between 1970 and 1987 are also based on the figure:

Period	Mean Yearly Growth in Total Capacity, GW
1970-1975	11.0
1975-1980	14.0
1980-1985	23.4
1985-1987	16.0

The economic advantages of electric power plants have been proved by their operating experience. This has lead not only to their development in countries that had already embarked on this path but also to the beginning of the construction of AES in such countries as China, Cuba, Poland, and Romania and to the design of AES in a number of other countries throughout the world. New construction and design of AES are presently underway in nine countries throughout the world.

Unfortunately, the existing literature on AES contains little or virtually nothing about their ecological advantages, including with regard to radiation. Furthermore, atomic bombs and accidents at the U.S. nuclear power plant Three Mile Island and in the USSR at the Chernobyl AES have facilitated the rather extensive propagation among the public, including in the USSR, of prejudice against the development of nuclear power generation in view of its apparent negative radiation effect on the biosphere. In fact, things are just the opposite. From the standpoint of its effect on the biosphere (including its radiation effect) nuclear power generation has indisputable advantages when compared with all other industrial enterprises. It should above all be remembered that mankind has always been and will always be under the effect of ionizing radiation. Among the radiation sources that do not depend on human activity are cosmic rays and ground radiation. When they interact with atmospheric air, cosmic rays form secondary cosmic radiation. Ground radiation is linked with the content in the earth's core of such radioactive elements as uranium, thorium, radium, radon, and potassium radionuclides.

The equivalent dose, which allows for all forms of radiation including those connected with human activity, is currently measured in sieverts [Sv]. This unit is related with the biological equivalent of the roentgen (ber) by the following relationship: 1 ber = 0.01 Sv, i.e., 1 mSv.

Then, in accordance with another work,[1] the following are the yearly doses of background radiation to the public that are unrelated with human activity:

City	Dose,μSv/y
Alma-Ata	1,600
Dushanbe	1,300
Leningrad, Tashkent	1,200
Irkutsk, Murmansk, Riga, Chita	1,100
Ashkhabad	1,050
Vilnyus, Lvov, Minsk	1,000
Kiev	950
Moscow, Petropavlovsk-Kamchatskiy, Tallin, Tbilisi	900
Astrakhan, Novosibirsk, Orenburg	800
Baku, Vladivostok, Yerevan, Khabarovsk	750
Sochi, Yakutsk	700
Kishinev	600

The natural radiation background is thus rather high, although it does differ by locality. The intensity of cosmic radiation depends on altitude. Thus, if it amounts to 350 μSv/y at sea level, it increases to 1,200 μSv/y at an altitude of 5 km and to 10,000 μSv/y at an altitude of 10 km (the flight of modern airlines). Ground radiation values differ as well. On average, at an altitude of 1 m above the earth the intensity of ground radiation amounts to 0.5 μSv/y. There are, however, regions of the earth (for example, regions of deposits of phosphorites, brown and bituminous coals, shales, etc., and, even more so, regions of uranium deposits proper) for which the intensity of ground radiation amounts to 5 and even 20 μSv/y.

Besides natural sources of ionizing radiation, there also exist radiation sources connected with human activity. For example, there are global radiation sources caused by the effect of nuclear explosions and a number of others. The following amounts are based on average data for the territories of the USSR for 1980 and 1981.[2]

Radiation Source	Radiation, μSv/y
Natural background	1,000
Radiodiagnosis	1,400
Construction materials	1,050
Global	25
Coal-powered TES	2.0
AES	0.17

It is evident from a comparison of the yearly radiation doses from TES (2 μSv/y) and from AES (0.17 μSv/y) with the natural background (1,000 μSv/y) that the main effect of radiation is not related to fossil fuel-powered, much less nuclear-powered electric power plants.

It should be recalled that practically all human industrial activity involves factors that are harmful to the environment to some degree or other. It generally turns out that the radiation background for TES burning coal is 10 to 15 times higher than that for AES. This is linked to the coals' content of certain long-lived radionuclides, for example, radium-226 and radium-228, which are emitted together with ash. Of the solid fuels burned at TES, oil shales should particularly be singled out since their ash contains a definite quantity of uranium-238, thorium-232, and potassium-41. Kukruze oil shales contain 10 g uranium per ton of shale [such shales are permissible for burning]; dictyonomic shales contain up to 100 g uranium per ton [burning of these shales is not permitted]. Unfortunately, dosimetric services have not been organized in the shale-powered Estonian and Baltic GRES, although they are needed.

Nuclear power generation has the least effect on the environment. This is largely explained by the fact that any other industrial enterprise may (although not necessarily) operate without fully scrubbing the gas and liquid wastes that it emits. Cleaning systems are stipulated in the plans but are generally either not included at all or else are included at only partial capacity. For a nuclear power plant, the scrubbing systems (filtration of gas wastes, evaporation and solidification of liquid radioactive wastes) are an organic component of the AES itself. An AES cannot possibly operate without the scrubbing units being turned on.

We will examine the effect of an AES on the environment compared with that of a TES or even a GES on top of the aforementioned effect on radiation conditions.

We will begin with oxygen consumption. TES consume it to burn fuel, and GES consume it for oxidation of the wood that is generally burned when its water reservoirs are organized. An AES does not consume oxygen at all.

As a result of the burning of fossil fuel, TES dump enormous amounts of ash, sulfur oxides, and nitrogen oxides into the atmosphere. The latter appear to be carcinogens. The enormous amounts of carbonic acids that are emitted also worsen the status of the atmosphere (the "greenhouse effect"). Many industrial, particularly chemical and metallurgical, enterprises act analogously.

The press has recently recalled ever-increasing cases where the scrubbing equipment of different plants has either not been used or else only partially loaded. As a result, not only rivers (even spring floodwaters) but even the seas are in a sorry state. Nothing similar can happen because of AES.

It is interesting to note that even GES have a negative impact on people's health. In the Krasnoyarsk Oblast the presence in the air medium of very fine granules of icicles causing upper respiratory tract illness and, moreover, retarding development of the upper respiratory tracts in children have thus been noted. Fog over the water reservoirs of GES hold toxic wastes over a city.

Conditions in the region of the activity of AES are thus more favorable from the standpoint of ecology. Of course this is only correct in the case where production regulations are strictly observed. Failure to observe the production regulations for AES may have serious consequences, which the public knows well. Unfortunately, it is not widely known that the accident in Chernobyl was only a flagrant violation of the production regulations. Furthermore, design changes that would cause the reactor to shut itself down in the event of attempts to violate the regulations are currently being introducing for existing reactors of the Chernobyl type.

Public prejudice against nuclear power generation is also connected with the complete absence of publications dealing with radiation conditions in the regions where AES are located. It is known that under the normal operation of AES observations are continuously made by internal and external dosimetry laboratories, i.e., both at the AES itself and at different distances from it, including a 50-km zone. Why are these data not published at least periodically? A respective "roundtable"

should probably be organized on Central Television, and leading specialists from existing AES should be invited to take part. If AES personnel had reason to fear the radiation level at the AES residential settlement, for example, the tens of thousands of specialists living at AES settlements with their families would certainly not be working at AES in the USSR.

The journal TEPLOENERGETIKA (No 2, 1989) published data on the radiation conditions around the Novovoronezh AES. It should that in the more than 24 years for which the AES has operated its contribution to radiation conditions has not exceeded 8 percent of the limit allowable norms. Systematic publication regarding the radiation conditions around AES will permit the public to form a well-founded opinion regarding the actual safety of AES.

The potential hazard of nuclear power generation exists and must not be forgotten. It requires the most careful attitude to matters related to the design, erection, and operation of AES. Minimum risk and maximum reliability must be guaranteed. In view of this, policies for nuclear power generation should be developed since there is no alternative to it. The public should known that the development of nuclear power generation adopted by the 27th CPSU congress does not conceal any hazard.

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Stray Current Elimination Discussed

907F0050A Moscow STROITELNAYA GAZETA in Russian 3 Sep 89 p 3

[Article by L. Kaybysheva under the "Scientists' Quest" rubric: "The Secret of Stray Currents: Researchers Solve the Problem of Power Supply Reliability"]

[Text] Novosibirsk—No one knows for certain the direction in which grounded currents escape, nor is it generally known what they are. It is as though these currents—which had been thought of as insignificantly small—had not been noticed until recently.

However, it has come to light that these weak fluxes of electrons escaping into the earth also break down the ions of metal grounding devices, i.e. destroy them. They also destroy concrete: cracks appear in it into which water and sand fall. So power transmission line supports and substations can break down imperceptibly, with a concomitant serious disruption to consumers' power supplies. The problem has become more challenging with the increase in the category of power transmission line voltages and substation capacities.

In buildings, water pipes are often used as grounds. A mass of piping, cables and other metal has been laid in the ground. When selecting the easiest path, the currents will first choose metal conducters without fail. But they also travel fairly well through normal soil, and more freely through sand than clay. The composition of the salts, density, moisture, gas content temperature and other soil characteristics effect their speed and direction.

It turns out that concrete structures as well as grounding devices can be competently designed and their reliability predicted only when the nature of the stray currents in a given region are known. SibNIIE [Siberian Scientific Research Institute of Electricity], the All-Union Scientific Research Institute of Direct Current, Energosetproyekt [All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks], the Kazakh Agricultural Institute, MGU [Moscow State University] and other institutes are all working on this problem. But SibNIIE is the focal point of this research.

And it was no accident that the All-Union Seminar on Underground Currents was held recently right in Novosibirsk. Specialists reported here on their hypotheses, calculations and methods for metering the activities of these currents in practice.

For example, Professor Yu. Tselebrovskiy of Novosibirsk has led the way in developing principles for calculating pulsed underground currents for various soils for gas and oil field workers in the Tyumen North. Unfortunately, this valuable work has been met with a less than enthusiastic response by the client—Giprotyumenneftegaz [State Institute for the Planning of Petroleum and Gas Industry Eneterprises, Tyumen Oblast]. Here, they prefer to spend large sums of money to conduct their own full-scale surveys of the electrical characteristics of the soils. They even cancelled their contract with the scientific community at mid-point because of a shortfall of funds, even though the proposed calculations would have effected direct savings.

Under the leadership of Yu. Demina, head of the Department of Electrical Conductor Design, a number of original works have been completed in investigating stray currents. Specifically, the Kazakh scientists, working in association with Turkmenenergo and the central Asian institute Energosetproyekt, were the world's first to conduct experiments on rural 0.4 kV power transpmission lines. Regional charts of the expected service life of reinforced concrete structures in saline and non-saline soils were drawn up, taking ground water, high temperatures and other factors into account. The maps were used to construct mathematical models for designers and operational personnel. It was found that even using standard designs, but selecting the type according to specific conditions, the power transmission lines' expected normal service life could be significantly extended. Sometimes it is more convenient to detour power transmission lines around salt bottoms rather than erect them in a straight line, as is usually done. It was found in the test area near Ashkhabad that a metallic, epoxy or bitumen sleeve should be mounted on the part of the structure where the concrete heats up to 32 degrees, as the concrete actually draws sulphate solutions—sulphuric acid salts—out of the ground by this part which warms up.

The corrosion rusts the grounding device not so much below ground as at the boundary of the atmospheric air and the soil. This also acts as an "opening" for stray currents. Perhaps it might be useful to insulate all the foundations with epoxy.

None of these defects should be attributed to nature. Roughly half of them are caused by negligence on the part of the builders and repair workers who are not power engineering personnel who damage the structures, grounding devices and even cables in the course of their work.

As such, these are the "invisible" facets of the problem of reliability and economy of the power supply which should be taken into account in practice.

UDC 621.311:621.311.21.001.8

Establishing Feasibility of Sequence and Time Frames of Introducing Hydraulic Power-Generating Units in Power Generation System

907F0009B Moscow ELEKTRICHESKIYE STANTSII in Russian No 7, Jul 89 pp 16-18

[Article by V. S. Sharygin, doctor of technical sciences, Northwestern Department, All-Union State Planning and Surveying and Scientific Research Institute of Power Generation Systems and Networks (Energosetproyekt) under the "Optimizing the Structure of Generating Capacities" rubric: "Establishing Feasibility of Sequence

and Time Frames of Introducing Hydraulic Power-Generating Units in Power Generation System"; first paragraph is ELEKTRICHESKAYA STANTSII commentary originally published following the article]

[Text] The problem examined in this article is of interest for the practice of designing the future development of power-generating systems. The editorial staff also considers it necessary to note that this article must not be used as a basis for unequivocally concluding that the proposed method has any advantages over existing methods. A deeper comparative analysis of the methods along with calculations made during the actual design process is necessary.

In each subsequent stage of the development of electric power generation systems it is usually possible to erect a number of hydraulic power-generating units (hydroelectric stations [GES] and hydroelectric pumped storage power plants [GAES]) that may differ significantly from the standpoint of their efficiency.

In view of this as well as the constraints on the use of their capacity in the load graph, the task arises of selecting a feasible sequence and time frames for introducing hydraulic power-generating and other rival peak power-generating units with a limited daily power resource (air-pumped storage gas turbine electric power plants [VAGTES]) in an electric power generation system.

Direct comparison and decision making proceeding from a minimum of inherent costs in the power-generating units is inadmissible since they differ with respect to power generation indicators and the nature of their use, which means that they also differ with respect to their effect on the structure of the generating capacities and mode of an electric power generation system, which it turn results in the inequality of rival power-generating units from the standpoint of their attendant (related to their introduction) system costs.

The existing methods assume that the effectiveness of power generation facilities with respect to the national economy is determined by their economy as compared with the versions of developing the generating capacities of an electric power generation system that they are replacing rather than compared with one another.

It is thus more valid to compare rival power-generating units with respect to the cost savings resulting from their introduction than to compare them with the version they are replacing, i.e., those units affording the greater savings will be more economical.

This type of rather simple solution of the problem is, however, only possible under conditions where the power-generating units under examination do not exert any mutual effect on one another's efficiency.

In reality, by replacing a specific portion of an electric power generation system's load graph, previously introduced units change the nature of the use of the system's capacity and the effect the power-generating unit that is introduced next will have on the power generation system. This is expressed in their system efficiency indicators and in the principal system parameters (installed capacity and daily power resource of the power-generating unit).

It follows from this that, given the possibility of erecting a number of peak power-generating units in an electric power generation system, their joint technical and economic justification is required. This includes selecting a feasible sequence and time frames for introducing the power-generating units and feasible system parameters. (In present design practice, peak power-generating units are generally justified independently of one another by proceeding from the introduction sequence and time frames that have been adopted on the basis of general considerations and for which the power-generating units' system parameters are also selected.)

In the formulation of the task that has been presented, which stipulates examining all possible combinations with regard to the introduction sequence and time frames and the parameters of the power-generating units, performing the task strictly requires using dynamic programming methods that are rather laborious and complicated for practice.

Under these conditions it appears more efficient to use the method proposed below, which is based on the method of decomposition, i.e., to perform the task in parts with a subsequent iterative linking of the results.

The method, which was originally presented elsewhere,[1] conditionally (under the assumption that each of the power-generating units examined is introduced first) selects their system parameters and, for the parameters preliminarily adopted on this basis, determines the feasible sequence and time frames for introducing power-generating units into the system.

Their parameters are refined for the sequence and time frames of introducing the power-generating units that are thus obtained, and the calculations are repeated to determine a feasible sequence and time frames for introducing the power-generating units until the results converge for practical purposes (generally two or three iterations of the calculations are sufficient).

The efficiency criterion in the specified calculations, as in the case where a power-generating unit is justified independently, is the derivation of the maximum possible reduction of adjusted costs as compared with those for the version of developing the electric power generation system that is being replaced.

In the given case, where an entire set of power-generating units is being compared, the most feasible version is that in which their development is characterized by the greatest total reduction in dynamic adjusted costs for the entire period of the electric power generation system's development that is affected by the introduction of the power-generating units under examination.

To make the versions being compared comparable from a power engineering standpoint, in each year of the specified period they are reduced to an identical effect with respect to total usable capacity and power production.

The marginal power balance in the respective zones of the load graph of the electric power generation system of an electric power plant (gas turbine power plant [GETS], POKES [not further identified], etc.) is assumed to be equalizing.

The most complicated thing in the specified calculations is determining (for each year of the calculation period) the costs of the version of the power-generating unit that is being replaced by the versions of power-generating units under examination corresponding to the versions of introduction sequences and time frames and parameters that are being examined. These must in principle include an allowance for all of the changes in the structure of the generating capacities and mode of the electric power generation system that are related to their introduction.

A method proposed elsewhere[2] may be used for this purpose. In accordance with this method, nomograms of the change in the specific adjusted costs of the version that is being replaced by the power-generating units that are being justified (for the same sequence of introduction) as a function of the installed capacity and daily number of hours it is used are constructed on the basis of calculations optimizing the structure of the electric power generation system for the stages of its development that are being examined. By using the specified nomograms, it is rather simple to determine the costs of the version being replaced for all of the development versions and parameters of the power-generating units that are being justified (for all combinations of their installed capacity and daily power resource) during the comparison process.

A program has been developed for YeS computers to reduce the laboriousness of the calculations.

Practical calculations using the specified program were performed for the United Power Generation System of the North and West based on the example of the three peak power-generating units that could possibly be erected during the period from 1991 to 2000: GES, GAES, and VAGTES. The calculations were performed for system parameters (Table 1) adopted on the basis of preliminary calculations that were later refined to obtain the optimum sequence and time frames for the power-generating units (as a result, several parameters of the GAES were changed).

Table 1

Parameter	GES	GAES	VAGTES	Total
Installed capacity, MW	300	1,300	500	2,100
Daily power resource, millions of kWh	1.5	7.3	2.5	11.3
Daily no. hours capacity is used, h	5.0	5.6	5.0	5.4

In the stage of its development under examination, the demand on the power generation system at peak capacity ranges from 150 to 1,500 MW. Under these conditions, the capacities of the units being justified will be used completely by 2005, which determines the duration of the calculation period under examination.

The following versions of the sequence of introducing power-generating units have been compared:

GES, GAES, VAGTES;

GES, VAGTES, GAES;

GAES, GES, VAGTES;

VAGTES, GES, GAES.

(Considering the high design readiness and work that is done with regard to preparing the construction of the GES under examination, its position of introduction in the specified sequences was never assumed to be after the second position.)

Eight versions of the time frames for introducing power-generating units with even intervals of introducing the subsequent units (after 2, 3, and 4 years) were examined for each of the above sequences. Uneven intervals (for example, the second unit after 2 years and the third after 4 years, etc.) were also examined.

The specific costs of the version being replaced and the power-generating units' usable capacities were determined on the basis of calculations optimizing the structure and insertions in the power generation system's load graph for the "borderline" years (1995, 2000, and 2005). They were also obtained for the remaining years of the calculation period by interpolation.

Next, in accordance with the method presented and by using the specified program, calculations were performed to compare the possible versions of the electric power generation system's development (computation time on a YeS-1045 computer, 10 minutes). Table 2 presents the total reduction in dynamic adjusted costs (compared with the version of developing the power generation system that is being replaced) in millions of rubles per year.

Table 2

Version of sequence in which power-generating units are introduced	After 2 Years	After 3 Years	After 4 Years
GES, GAES, VAGTES	4.54	4.99	4.74
GES, VAGTES, GAES	-4.23	-2.24	-7.36
GAES, GES, VAGTES	9.49	10.46	10.29
VAGTES, GES, GAES	-5.88	-2.0	-9.61

Analysis of the results showed that, depending on the introduction sequence and time frames, the efficiency of individual power-generating units (like the versions of their development as a whole) changes significantly, all

the way to a change from being efficient when one sequence of introducing the power-generating units is used to the ranks of inefficient when another sequence of introduction is used. The latter applies to GES and VAGTES, whereas GAES are efficient (but to a different extent) in all possible versions of the sequences and time fames of introducing the power-generating units under examination.

The calculations performed confirmed that power-generating units with a restricted daily power resource may exert a significant mutual effect on each other's efficiency. It is therefore incorrect in the general case to justify and select the system parameters of power-generating units independently and to introduce them in any, possibly nonoptimum sequence since this may result in significant losses.

For the example examined, the total dynamic adjusted costs in the most advantageous version of the sequence in which the power-generating units are introduced (the GAES first, the GES second, and the VAGTES third) reach (when their introductions are spaced 3 years apart) 10.46 million rubles per year as compared with a cost with the worst version that is 5.88 million rubles per year higher. The savings from selecting the most economical spacing of the introduction of the second and third units in the optimal sequence amounts to approximately 1 million rubles per year.

The specified data graphically confirm the significant margin of cost savings in an electric power generation system owing to rational selection of the sequence and time frames in which peak power-generating units that can possibly be erected are introduced.

Conclusions

1. The task of joint justification, which includes selecting both the feasible sequence and time frames of introducing power-generating units and their system parameters, has arisen as a result of the differences (from economic and power generation standpoints) between hydroelectric and other peak power-generating units with a limited daily power generation resource that can possibly be erected, as well as because of their mutual effect on each other's efficiency.

2. The specified task should be performed by comparing the possible versions of the sequence and time frames of introducing the entire set of power-generating units that are being justified, along with their system parameters (with respect to the amount of the total savings in dynamic adjusted costs as compared with the version of developing the power-generating capacities of the electric power generation system that is being replaced).

3. Calculations related to the joint substantiation of the power-generating units (GES, GAES, and VAGTES) that could possibly be erected in the period up to the year 2000, which were made using the example of the United Power Generation System of the North and West, showed that a very significant cost savings can be obtained in the power system by rationally selecting the system parameters of power-generating units and the sequence and time frames in which they are introduced.

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Abstracts Appearing in 'Bulletin of Armenian SSR Academy of Sciences: Mechanics Series'

907F0001A Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: SERIYA MEKHANIKA in Russian Vol 42 No 2, Jul-Aug 89 pp 58-59

[Abstracts appearing in "Bulletin of Armenian SSR Academy of Sciences: Mechanics Series," July-August 1989]

[Text]

Effect of Magnetic Field on Modulation Waves in Plate and Cylindrical Shell. A. G. Bagdoyev, L. A. Movisyan, pp 3-12

This work derives a modulation equation for a nonlinearly elastic plate with finite conduction in a longitudinal magnetic field. The effect of magnetic viscosity on the stability of modulation waves and convective and absolute stability are discussed.

The effect of velocity and magnetic field on the flutter and stability of modulation waves is investigated for a cylindrical shell. Figure 1, references 14.

Magnetoelastic Stability of Thin Bodies Serving To Transport Electrical Current. M. V. Belubekyan and K. B. Kazaryan, pp 13-21

This work presents a review of the research on the stability of elastic thin-walled structures with an electrical current that exists in the scientific literature. References 42.

Seismic Vibrations of Round Die on Multilayer Inhomogeneous Base. S. S. Darbinyan, M. V. Oganesyan (deceased), and A. Ye. Sargsyan, pp 22-34

The interactions of structures in the form of a round plate with a transverse-inhomogeneous base and the determination of the wave load on structures based on a single dynamic circuit are examined in accordance with the Green function method using a convolution theorem based on a Fourier-Bessel transform. Integral motion equations are solved in accordance with the mechanical quadratures method, resulting in the derivation of patterns of the distribution of dynamic contact stresses and displacements with an allowance for the diffraction of waves on the contact surface, interference, and dissipation in a laminar medium given different values of the key characteristics of the medium and external effect. Table 1, figures 5, references 9.

One Version of Different-Modulus Elasticity Theory. A. A. Khachatryan, pp 35-40

This work is devoted to a discussion of the results of a previously published article in which a new version of the different-modulus elasticity theory is proposed.

The research resulted in the conclusion that the specified work has nothing in common with different-modulus elasticity theory since the results obtained on the basis of the assumptions made there are reliable only for conventional (single-modulus) isotropic material. References 7.

Thermal Shock in Thin Wafer With Crack in Presence of Heat Exchange With Environment. V. A. Kozlov, V. G. Mazyya, and V. Z. Parton, pp 41-49

Thermal shock, i.e., the effect of stresses caused by a sharp change in temperature in a thin wafer with a rectilinear crack is investigated with an allowance for heat exchange occurring in accordance with Newton's law. A representation is found, and the asymptotics of the stress intensity coefficient are derived. References 2.

One Problem of Elastic Half-Plane Weakened by Cracks. B. A. Afyan and S. P. Stepanyan, pp 50-57

This article examines a plane elasticity theory problem about the stress-strained state of an elastic half-plane containing one finite and three semi-infinite cracks. The problem is reduced to the solution of a system of two singular integral equations with Cauchy kernels. An approximate solution of the system of integral equations is constructed by the Erdogan-Gupta method. Numerical values are obtained for the coefficients of the intensity of the stresses at the ends of the cracks. Tables 2, figures 3, references 5.

UDC 621.793:629.199

Acoustic Emission Strength Criterion for Composite Materials

907F0059A Moscow IZVESTIYA VISSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 9, Sep 89 pp 25-29

[Excerpts from an article by V. V. Nosov, candidate of technical sciences, and S. V. Nosov, engineer; first paragraph is IZVESTIYA VISSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE abstract]

[Excerpts] An acoustic emission criterion is proposed for the strength of composite materials and represents the parameter of the kinetics of the accumulation of acoustic emission signals when specimens are loaded at a constant rate. The values of the criterion may be determined quickly and in a nondestructive manner, which makes it possible to use them for individual monitoring of the fatigue life of composite materials when optimizing the technology used to manufacture them.

In recent times, composite materials have enjoyed wide-scale use in machine building. The main criterion for the fatigue life of components and structures manufactured from them is strength, the value of which, as is common knowledge, is characterized by a large spread and depends largely on technological and use factors. This explains the great importance of new methods of monitoring the strength of composite materials that, on the one hand, would make it possible to sort components in accordance with the results of an individual assessment of their fatigue life and, on the other hand, make it possible to quickly assess the quality of components immediately after they have been manufactured and thereby facilitate optimization of the technology used to manufacture them.

The most effective approaches to solving these problems are those that consider the physics of the processes leading to the failure of the objects under investigation, which makes it possible to forecast their fatigue life.[1] Numerous research projects by Soviet and foreign scholars have shown the adequate efficiency of using acoustic emission methods. However, the problem of selecting the most informative acoustic emission strength criteria has not been solved. [passage omitted]

As experiments have shown, the values of the proposed acoustic emission strength criterion do not depend on the geometric features of the specimens being tested, the method and quality of attaching a sensor, or changes in the gain factor of the acoustic emission measurement system during the transition from test to test since the effect of the specified factors is reduced solely to the parallel transfer of the graph of lnN(t) up or down.

The acoustic emission strength criterion for composite materials that has been proposed on the basis of a kinetic approach to forecasting mechanical failure thus makes it possible to assess a material's quality quickly, sufficiently precisely, and nondestructively. This offers the promise of an individual approach to forecasting the fatigue life of components and structures and makes it possible to accelerate the development of optimum production modes.

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UDC 621.865.8.002

Functional Organization of Program Modules for Robotic Production-Process Systems CAD

907F0059B Moscow IZVESTIYA VISSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 9, Sep 89 (manuscript received 9 Sep 88) pp 41-44

[Article by Yu. T. Kaganov, candidate of technical sciences, and V. V. Kaganova, candidate of technical sciences and docent; first paragraph is IZVESTIYA VISSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE abstract]

[Text] We will examine the possibilities of standardized implementation of CAD system functional program modules for robotic production-process systems.

To ensure that it will be flexible and that it can be enhanced and modified, a CAD system should be developed on the basis of the modular principle. This is also necessary because there are a great number of programs and applications packages that may be very useful when developing a CAD system. For example, they include programs investigating the kinematics and dynamics of mechanisms and programs based on the use of finite element methods. There is no need to develop the algorithms for these programs anew. But since a system tie-in is necessary, these programs require careful modification and adaptation to the requirements of industrial robot CAD systems. Implementation of functional program modules must be standardized. Each functional module consists of tools for interaction, processing of information and computations, and visualization.

Interaction tools are intended for inputting source data and checking them, as well as for tracking the decision process and managing the information processing process. Information and computation processing tools serve in processing information and in numerical analyses when the respective programs are used. Visualization tools are intended to output the end results onto the screen of a graphic or alphanumeric display as well as to an alphanumeric printer and graph plotter.

Each of the parts is, as necessary, linked with the respective data stored in a data base via system managing these data. We will examine the specific implementation of the program modules by way of the example of modules entitled "Selecting a Manipulation System Block Diagram" and "Optimization." The implementation of other program modules is analogous (Figure 1).

The functional organization of the program module "Selecting a Manipulator's Block Diagram" (Figure 2) and those of analogous selection modules (Figures 2 and 3) is as follows. The manipulation system's source parameters, the size of the working and service zone, the number of degrees of mobility, and other constraints on it are input in an interactive mode. Next, the data based management system managing the data in the block diagram catalogue is used to retrieve the respective block diagram. If the block diagram found does not satisfy the designer, he either replaces it or adds to it. If the specified block diagram is not found, a new block diagram is written into the block diagram catalogue. Next, the characteristics of the manipulation system's links are determined on the basis of the resultant lengths of the manipulation system's links, the proposed material, and the approximately determined cross section. The extreme trajectories of the motion of the industrial robot's end-effector are input, and the manipulation system's dynamic characteristics from the standpoint of natural vibrations and forces in the kinematic pairs, etc., are calculated. If they satisfy the designer, the mechanical diagram produced as a result of the design process is output to a display screen and graph plotter, and the design parameters are output to an alphanumeric printer. This information is refined at the second level.

The functional organization of the optimization program module (Figure 3) is as follows. All optimization tasks may be subdivided into three types. The first type are well-structured tasks. They include those tasks in

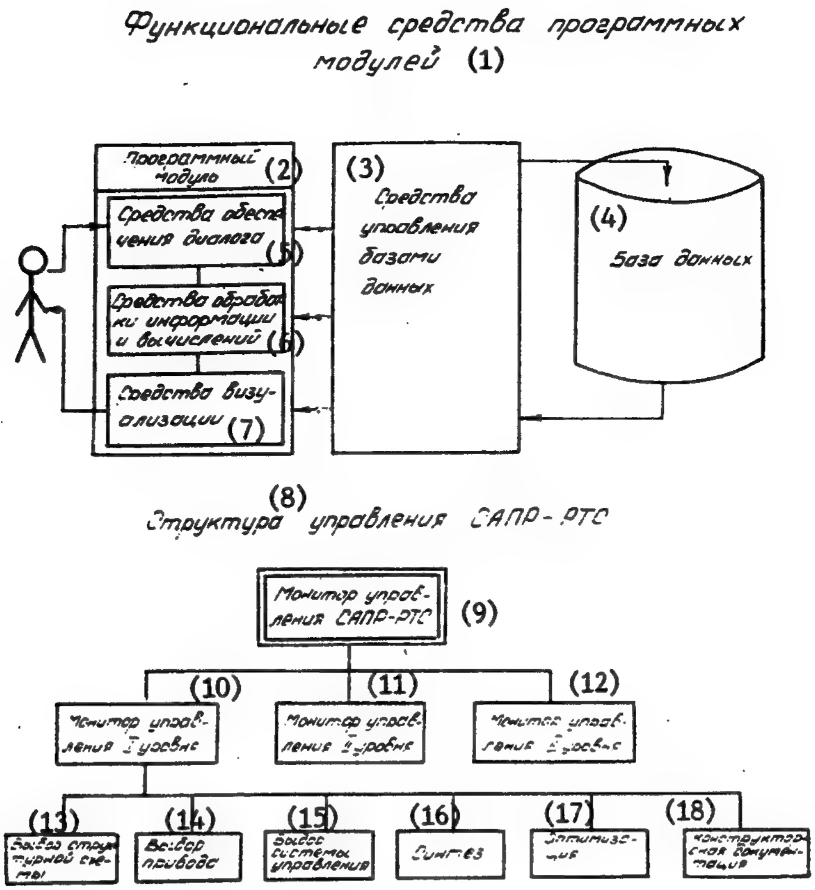

Figure 1

Key: 1. Program module's functional tools 2. Program module 3. Data base management tools 4. Data base 5. Interaction tools 6. Tools for preparing information for processing 7. Visualization tools 8. Structure of control over robotic production-process system CAD system 9. Monitor of control over robotic production-process system CAD system 10. Level I control monitor 11. Level II control monitor 12. Level III control monitor 13. Selection of block diagram 14. Selection of drive 15. Selection of control system 16. Synthesis 17. Optimization 18. Design documentation

which the constraint functions and criteria may be rather distinctly formalized. These are static optimization tasks. Such tasks generally constitute the majority, and they may be performed by using conventional nonlinear programming methods.

The second type are poorly structured tasks. They include tasks where the functions of both criteria and constraints cannot be expressed in the form of explicit functions that are dependent on the optimization parameters. In this case it is necessary to use special methods based on the use of Monte Carlo methods.

The third type are optimum control tasks. Such tasks arise during investigation of the industrial robot's dynamics and selection of the control law. They also require specific optimization methods. However, the individual programs and subroutines used in accomplishing all three types of problems may be rather standardized and are used independently of the type of task being performed. The optimization process may be represented as follows. The boundary values of the parameters and constraints, the names of the respective optimization models, and the sizes of the admissible errors are input in an interactive mode. Coefficients of the relative preferences of the criteria and constraints are also input when performing multicriterial optimization tasks. Intermediate data related to tracking the decision process is output to the display screen during the computation process. If the resultant decision satisfies the designer, he may cease the computation and proceed to the next step—visualizing the result. In this case the result may be output to a display screen in the form of a respective graph or table and then printed out on an alphanumeric printer.

Optimization methods may be used to retrieve an optimal configuration, (i.e., the lengths of links and constraints on mobility) of a manipulation system, optimize the parameters of drive elements and a manipulation system's mechanisms, retrieve an optimum control law,

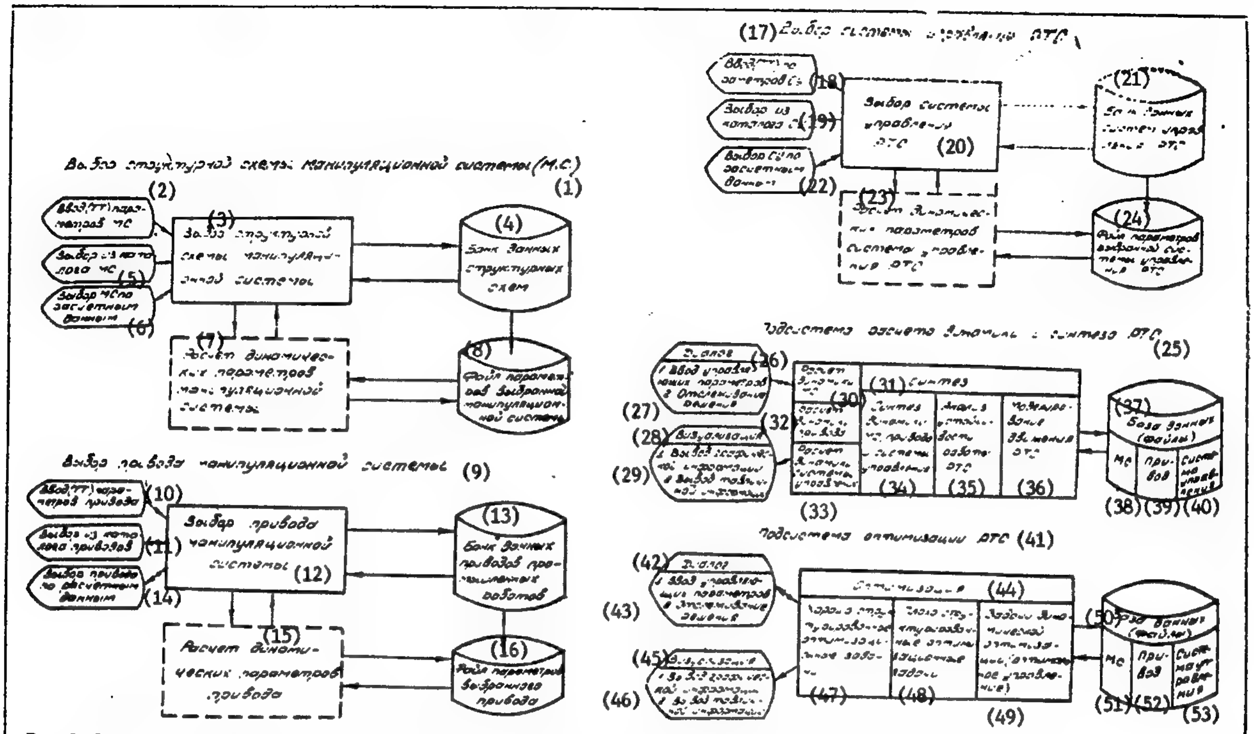

Рис. 2. Основные подсистемы САПР робототехнических систем

Рис. 3

Figure 2. Main Subsystems of the Robotic Production-Process System CAD System

Key: 1. Selection of block diagram of manipulation system 2. Input (TT) of manipulation system's parameters 3. Selection of manipulation system's block diagram 4. Block diagram data bank 5. Selection of manipulation system from catalogue 6. Selection of manipulation system based on calculated data 7. Calculation of manipulation system's dynamic parameters 8. Parameter file for manipulation system selected 9. Selection of manipulation system's drive 10. Input (TT) of drive's parameters 11. Selection of drive from catalogue 12. Selection of manipulation system's drive 13. Data bank of manipulation system drives 14. Selection of drive based on calculated data 15. Calculation of drive's dynamic parameters 16. Parameter file for drive selected 17. Selection of control system for robotic production-process system 18. Input (TT) of control system's parameters 19. Selection of control system from catalogue 20. Selection of control system for robotic production-process system 21. Data bank of robotic production-process system control systems 22. Selection of control system based on calculated data 23. Calculation of dynamic parameters of robotic production-process system control system 24. Parameter file for robotic production-process system control system selected 25. Subsystem to calculate dynamics and synthesize robotic production-process system 26. Interaction 27. 1) Input of control parameters and 2) Tracking of decision 28. Visualization 29. 1) Output of graphic information and 2) output of information tables 30. Calculating the manipulation system's dynamics 31. Synthesis 32. Calculating the drive's dynamics 33. Calculating the control system's dynamics 34. Synthesis of dynamics of manipulation system, drive, and control system 35. Analysis of operating stability of robotic production-process system 36. Modeling robotic production-process system's motion 37. Data base (files) 38. Manipulation system 39. Drive 40. Control system 41. Subsystem for optimizing a robotic production-process system 42. Interaction 43. 1) Input of control parameters and 2) Tracking of decision 44. Optimization 45. Visualization 46. 1) Output of graphic information and 2) output of information tables 47. Well-structured optimization tasks 48. Poorly structured optimization tasks 49. Dynamic optimization tasks (optimum control) 50. Data base (files) 51. Manipulation system 52. Drive 53. Control system

approximate a real trajectory to a specified one, calculate an industrial robot's efficiency, and perform many other tasks.

UDC 621.961.2.073

Die for Piercing and Cutting

907F0053A Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 36-37

[Article by I. I. Davydov]

[Text] A series-action die with automatic band feeding and component removal has been designed and manufactured to produce long components like blades for a feed combine.

The lower (14) and upper (8) plates of the die are interconnected. The upper plate can move vertically with the help of guide bushings (11) along columns (13).

Dies are mounted on the lower plate through a puller (12) by means of a die holder. Mounted on the end of the puller that is located on the cantilever is a feed mechanism. Punches (7) and (9) are secured on the upper plate by means of a punch holder (10).

The feed mechanism (author's certificate No 1461567) contains a feed carriage (1) that is connected to a casing (3) that is connected to a shaft (4) through a spring-loaded key (2). The shaft has a helical groove passing into an open annular groove. A pinion that is engaged with a rack (6) that is secured to the die's movable upper plate is mounted on the shaft. A gripper (5) is hinged to the feed carriage.

Together with the movable part of the die, the press' ram moves downward, and the rack transmits the rotary motion to the shaft through a kinematic link and pinion. Through the key the shaft transmits a forward motion to the casing, which is connected to the feed carriage, which in turn moves along with the gripper in the direction of the feed and moves the material (band) an amount equal to the feed step. This makes the shaft rotate and the key move along the helical groove with a descent into the open annual groove.

When the production operation (piercing, cutting) is implemented, the rack and movable upper plate continue to move downward and turn the shaft. The immovable key, by entering the open annual groove on the shaft, stops the carriage with the gripper. After completion of the operation, the movable part of the die moves upward, and the working punches (7) and (9) move out of contact with the material. At the same time the key moves out of the open annual groove and, moving forward, comes into contact with the shaft's helical groove. The carriage returns to its initial position, and the gripper grips the material (band).

After the next lowering of the movable part of the die, the band, which is moved by the gripper, pushes out the previously cut component, and the cycle is repeated.

The die is designed for a model RDS-20M1 press and uses the complete press course. The die's overall dimensions are 1,600 x 450 x 280 mm. The extent of the feed is 620 mm. The die has a mass of 580 kg.

The economic effect from introducing the die in an annual program of 80,000 components is 4,000 rubles.

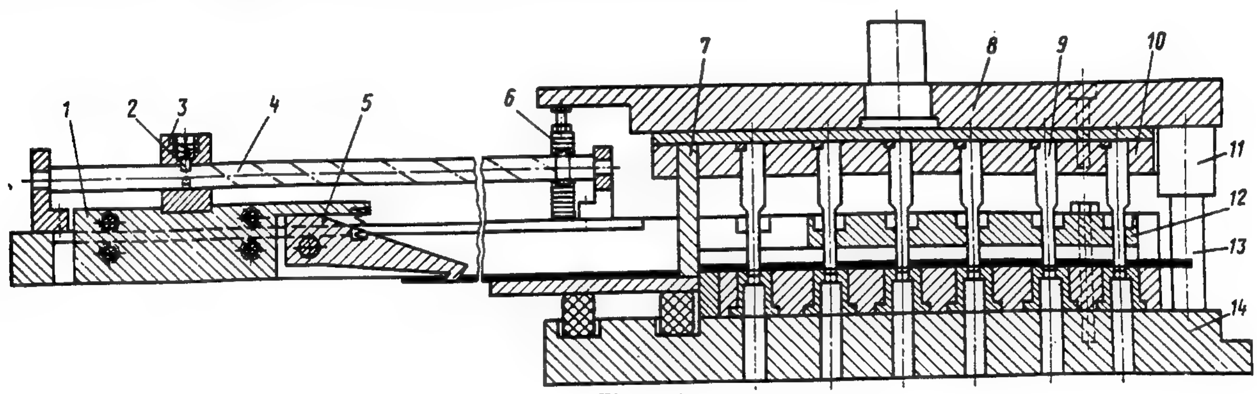

Figure 1

UDC 621.914.3

Machine Tool To Mill Oilways

907F0053B Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 37

[Article by F. A. Ozerov, A. G. Kruglov]

[Text] A machine tool to mill oilways in the lower tables of cylindrical grinding machines (author's certificate No 1333540) was developed at the Ukrorgstankinprom GPTEI [not further identified].

The machine tool consists of a bed (9) with guides (8) on which a П-shaped carriage (7) is mounted. The carriage has a groove (13) in which tie rods (12) can move

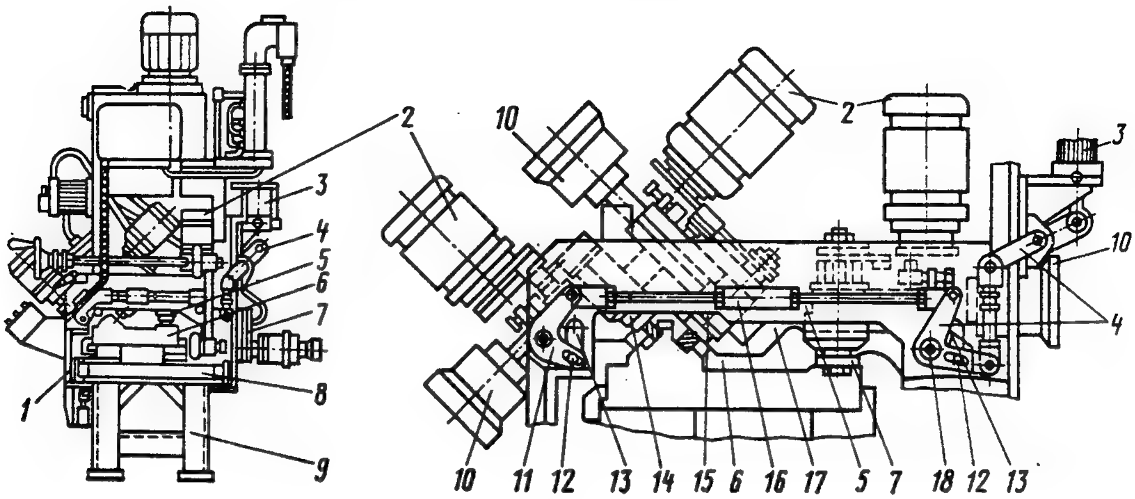

Figure 1

vertically. The latter are connected with an arm that is located on the carriage and that carries the tool heads (5), (14), and (15).

For the relative vertical movement of the carriage and arm, there is a drive that includes levers (11) that are connected with one another by a cross tie (16) and secured with the capability of turning on axes (18). The levers are part of a hinge-and-lever system (4) that is connected with a hydraulic cylinder (3). The carriage is equipped with additional Γ-shaped arms (1), the lower shelf of which rests in the bed. Hydraulic cylinders (10) and electric motors (2) are provided to drive the tool heads.

The tool heads (14) and (15) are located at a 90-degree angle relative to one another and opposite the prismatic guide.

The lower table of the circular grinding machine is mounted on the bed's bearing surfaces. Next, the carriage is mounted in the initial position for machining. The hydraulic cylinder's (3) rod, moving upward, acts upon the hinge-and-lever system. Under the action of the levers (11), which are connected by the tie rod (16), the tie rods (12) move downward, and the milling cutters in the tool heads are fixed to the parameters for machining the component (6). The arm (17) presses the component upward, and at the same time the carriage moves upward to the stop of the lower shelves of the Γ-shaped arms (1) into the bed. In this manner all of the machine tool's movable elements are self-configured along the contour of the component being machined and their clamp. Under the action of the hydraulic cylinders (10), the tool heads and milling cutters begin to move in a transverse direction relative to the table's guides, thus forming transverse oilways on the component. After the machining has been completed, the hydraulic cylinder's (3) rod moves downward, and the levers (11) raise the arm (17) holding the tool heads and withdraw it to the initial position. The carriage is lowered onto the guides and moves the established interval along the component being machined.

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Robotizing Machining Under Conditions of Redesigning Production

907F0052A Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 8-10

[Article by V. I. Zagurskiy, candidate of technical sciences, under the "Mechanizing and Automating Production" rubric: "Robotizing Machining Under Conditions of Redesigning Production"]

[Text] When creating multiple-machine tool robotic production-process systems it is necessary to strive to optimize the production and planning (configuration) decisions, consider organizational circumstances and the availability of trained personnel, etc. The robotization plan should be linked to such enterprise management functions as material and technical supply; technical-economic planning and operations scheduling; power, repair, and tool services to support production; personnel training; major construction; etc. The formulation of the goals of the robotization program should specifically reflect the end results, and the actually achievable time span required for finishing the operations should be designated.

The cost of robotization equipment frequently turns out to be not much less than that of basic production equipment. Another shortcoming of selecting industrial robots may be that the robot becomes a link in a robotic production-process system that restricts the technological capabilities of machining, above all, in view of a

discrepancy between its load-lifting capacity and the dimensions of the machine tool that it is servicing (in which case it is necessary to refrain from using a robotic production-process system to machine components that are too heavy even though the machine tool's dimensions permit the machining).

Yet another frequent trouble spot with industrial robots is insufficient speed and the related increase in the auxiliary time of an operation. If, for example, a shutdown of a robotic production-process system due to the replacement of a component lasts 0.5 minutes and the basic production time is a quantity with the same order of magnitude, robotization does not generally justify itself. In the given case, the basic production time should be no less than 3 minutes.

Multiple-machine tool robotization is resorted to to make more complete use of an industrial robot over time. But it is necessary to bear in mind that great enlargement of the transport system makes overall operation of a robotized system difficult and may reduce its efficiency, functional reliability, and operating time.

The possibility of having one industrial robot service a multiple-machine tool system is considered during design. Organization of the latter is made possible by the make-up of its production equipment, which has a similar loading circuit, and by the selection of a list of components that are close from the standpoint of configuration, which ensures sufficiently long-term operation of the industrial robot without retooling. The latter is implemented to the greatest degree in large-series-type production when a limited list of components is attached to the equipment serviced by a robot. A suitable period of time for machining components in a multiple-machine tool robotic production-process system is from 3 minutes on up.

Having one industrial robot service two to three machine tools is preferable. With the exception of cases in which hoist (gantry) robots) are used, having one industrial robot service more than four machine tools is not encountered in practice in view of difficulties in configuring and selecting components for loading and machining. In the case of a lesser (less than 3 minutes) piece time, the problem of organizing a multiple-machine tool robotic production-process system is generally not posed, i.e., the number of industrial robots in a design is selected equal to the number of equipment units being serviced. Surface and insufficiently reasoned economic validation of robotization plans and introducing industrial robots in an unsystematic manner does not permit loading robots fully enough. Robotized systems and complexes are poorly written into production with a conventional organization; it must be technically updated and subjected to organizational restructuring. The retooling of production for a new technology should be implemented on the basis of the integrated development of plans and specialization and concentration of the manufacture of products involving the use of group servicing of production equipment by a robot.

Under conditions of the intensive use of industrial robots, such requirements imposed on it as high reliability and speed, design simplicity, servicing with the guarantee of complete operating safety, and positioning precision assume the forefront.

At one Kurgan enterprise, the precision of having a robot configure shafts in lathe centers has been increased by using a movable rocking cradle (Figure 1) mounted together with a rod (9) and bracket (8) on the housing (10) of the machine tool's tailstock. The cradle is connected to a counterweight (11) and pressure strip (3). Its position is determined by the diameter of the component being machined and is fixed by a stop (4) and pin (6) mounted on a transverse support. By using a gripping device, the industrial robot moves the blank (2) to the machine tool's center line at one end and to the cams of the gripping chuck (1) and to the cradle at the other end, after which the gripping device withdraws and the blank is attached to the clamp at the rear center (7).

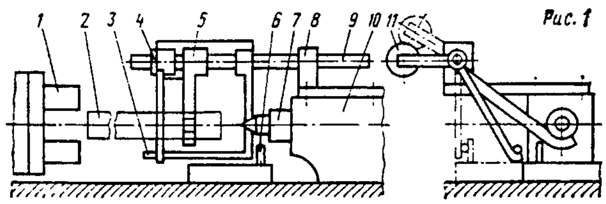

Figure 1

During the machining the pin (6) moves together with the longitudinal support by gliding along the pressure strip. The strip moves in an angular direction, and the cradle is moved out so as not to impede the machining of the component by the cutting tool or the departure of the chips. Under the effect of the counterweight, the cradle returns to its initial position and grips the component being machined when the longitudinal support is withdrawn.

The load on an industrial robot in robotic production-process systems is higher than in single-machine tool systems. The following information is analyzed to correctly plot the sequence of the industrial robot's actions during operation in accordance with the standard subroutine for a two-machine tool robotic production-process system in a wait mode: a query by machine tools for an object to service (proceeding from the presence or absence of workpieces being machined in the machine tools); the presence of workpieces in trays and cradles (which makes it possible for the robot to grip them); the presence of free places, i.e., positions in trays (which makes it possible to place workpieces); etc.

Requests for servicing are used in the first stage of having a robot load and unload machine tool positions. The transition to the second stage occurs when there are no such requests, and as a result, implementation of transport between machine tools and several other operations included in the industrial robot's program of

actions begins. After each of the subroutines is implemented, a return is made to the query stage so as to keep the machine tool's idle time to a minimum. In a multiple-machine tool robotic production-process system, after a specific machine tool is loaded or unloaded, a subroutine queries the other machine tools in the system regarding servicing. If one of the machine tools in the robotic production-process system is restrictive from a capacity standpoint, the Wait subroutine calls that machine tool first. A prevalent technique geared toward reducing equipment idle time consists of formulating a preliminary call after a specified time until machining of a workpiece has been completed, in which case the industrial robot has time to complete in advance such preliminary operations as, for example, taking a workpiece subject to machining and moving it to the machine tool. After the machining has been completed, there is a final call for the industrial robot to finish its actions with regard to loading and unloading the machine tool.

Forecasting queries to service machine tool positions in a robotic production-process system that are related to assessing the probability of a call before a higher-priority request arrives may lie at the basis of a Wait subroutine. This permits more rational servicing of machine tool positions and the development of auxiliary subroutines considering the running position of an industrial robot until a request for servicing the robotic production-process system's basic equipment arrives. Thanks to this more complex organization of control, the capacity of complexes and systems that are themselves characterized by a rather complex structure and operation is increased.

A probability approach is not resorted to in simpler cases. For example, in a model LAS ChPU 24 robotized quickly retoolable automated line (produced by the Machinery Plant imeni S. Orgzhonikidze), automatic loading of machine tools by a robot may be implemented in any sequence owing to reprogramming of the operation and RAM in accordance with the teach method. Control programs are stored on magnetic tapes.

During the course of a robotic production-process system's operating cycle there are time losses connected with loading-unloading and other auxiliary functions. In the case of manipulation by a two-grip device, these losses are reduced significantly as in the case of a rationally plotted operating graph for a industrial robot. In the robot control algorithm an allowance is made for waiting for a request that a machine tool be serviced. Depending on the situation, either servicing by an industrial robot (i.e., loading-unloading a machine tool) occurs, or else there is a transition to the execution of such auxiliary functions as laying workpieces in a tray and taking blanks from a magazine, which are done at the same time that the workpiece is machined on the machine tool.

Thus, the efficiency of using an industrial robot to automate machining is due not only to correct selection of the model of industrial robot used but also to the rational solution of an entire set of robotization problems entailed in computer-integrated manufacturing. The control program for an industrial robot servicing production equipment is determined both by the design of the industrial robot itself and the makeup of the robotic production-process system. Development of an algorithm for the functioning of the robotic system preceded direct programming.

An ever-increasing position is being given to simulation when creating a robotic production-process system with a high level of organizational structure. Computer programs that may be used to research and optimize the operation of a flexible manufacturing system [FMS] over time and thereby improve its structure and individual parameters are being created for this purpose. Accomplishing the task of synthesizing the structure of a complex FMS by this method is still difficult, but particular tasks have been accomplished successfully. One of them is that of analyzing the capacity of a robotic production-process system consisting of two sections (the layout of the equipment in this system is shown in Figure 2). Here the No 1 robotic production-process system is an ASVR-01 production system for machining shafts, and the No 2 robotic production-process system is a system for turning shafts with cycle times of 16 and 26 minutes, respectively. The numbers in Figure 2 designate the following: 1, the machine tool position for milling and drilling the center holes in blanks; 2A through 2E, model 1B732F3 NC lathe semiautomats; 3A and 3B, model UM60F3.81.01 industrial robots; 4A through 4D, intermediate (inter-machine tool storage units with capacities of 5 to 12 workpieces); 5A and 5B, storage units for machined shafts; 6 and 6A, storage units for blanks; 7A and 7B, intermediate transporters between the Nos 1 and 2 robotic production-process systems; 8, storage units located next to the machine tools (each with a capacity of two workpieces) (the broken lines indicate addition devices to establish an automatic transport link between the Nos 1 and 2 robotic production-process systems).

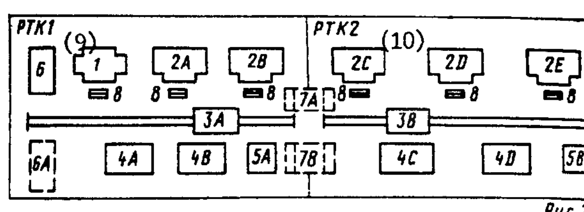

Figure 2

Key: 9. Robotic production-process system 1 10. Robotic production-process system 2

All of the blanks entering a section undergo milling and centering on the first machine tool (1); afterward the Nos 1 and 2 robotic production-process systems operate separately. The plans for the first robotic production-process system, after preparation of the bases, are transferred by the robot (3A) to a storage unit (4A); from there they are transferred to machine tools (2A) and (2B) for turning, and the blanks for the second robotic production-process system (after preparation of the bases on the same machine tool (1)) are transferred by a robot (3A) to

a storage unit (6A). From there a shop transporter feeds them to machine tools (2C) and (2D) that are serviced by a robot (3B). The finished components are sent by robot to storage units (5A) and (5B). Another machine tool (2E) is a stand-by.

The Machine Science Institute imeni A. A. Blagonrav of the USSR Academy of Sciences analyzed the capacity losses of a similar section as a function of the coefficient ρ of the business of the industrial robots, which equals the ratio of the mean time spent to transport a workpiece from the beginning of machining to the end to the mean total time required to machine the workpiece on all of the machine tools in the robotic production-process system. The capacity of the robotic production-process system during servicing by a robot (t goes to 0) was assumed to equal 100 percent for all operations. Values of the coefficient equal to 0.2 and 0.16 for the Nos 1 and 2 robotic production-process systems, respectively, correspond to the existing technology and organization of production. The first thought that comes to mind given the existing underutilization of both industrial robot sections over time is that its capacity could be increased by reducing (to one-fourth) the turning time.

Only when ρ equals 0.8 for the No 1 robotic production-process system and 0.64 for the No 2 robotic production-process system are the robots servicing the respective systems loaded so much that it is necessary to either increase their speed (i.e., install a different model industrial robot) or use a flexible manufacturing section with a different structure.

This example shows that equipping the Nos 1 and 2 robotic production-process systems with separate robots is justified in view of the rather small time required for the basic production equipment's operating cycle. At the same time, it is clear that given the existing technology and the shaft-machining capacity assumed for the machine tools in our example, it is advisable to design a link between the Nos 1 and 2 robotic production-process systems by using an intermediate transporter (7A) that simultaneously serves as the intake storage unit for the No 2 robotic production-process system. Both rotors (3A) and (3B) may have access to this transporter. The operation of a section may be organized such that the blanks for the No 2 robotic production-process system, after passing through the first machine tool (1), are transferred to the transporter (7A) by the robot (3A); the robot (3B) then takes the blanks from there and transfers them to the machine tools (2C) and (2D). In the given case, without diminishing the capacity of the two robotic production-process system sections, the robot 3A simultaneously services five machine tools on which both sets of components are turned.

However, at values of ρ equal to or greater than 0.4 for the first robotic production-process system and 0.32 for the second, the same organization of the section's operation entails significant capacity losses. This means that for a link between the Nos 1 and 2 robotic production-process systems, for example, in the case of respective values of ρ equal to 0.8 and 0.64, additional transport equipment is required. This additional equipment may be a robotized carriage.

Nothing was said above regarding considering the operating reliability of the production and auxiliary equipment even though mention was made of the stand-by machine tool (2E), which belongs to the lathe group and which assumes the function of the analogous machine tools in both robotic production-process systems in the event of a failure.

The problem of further wide-scale popularization of robotization in the field of machine building is not reduced solely to the successful use of existing and new industrial robot and production equipment designs. The following may be assumed to guarantee the efficient implementation of robotization: use of the most advanced (from a functional standpoint) production equipment; configuration of industrial robots used from standardized assembly units-modules; the capability of selecting a wide range of position hardware required to create flexible manufacturing modules, robotic production-process systems, and computer-integrated manufacturing systems; and the ease and speed of retooling robotized technology in multiple-product production (including automatic changing of the gripping devices of industrial robots themselves). Other ways of increasing the efficiency of robotization exist as well

UDC 621.865.8-113:621.757.06

New Robotized Assembly Method

907F0052B Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 10

[Article by V. N. Davygora, candidate of technical sciences, V. A. Kirilovich, and V. A. Orlyuk]

[Text] A new robotized assembly method (author's certificate no. 1458126) was developed at the Machine Building Department of Kiev Polytechnical Institute to expand the production capabilities and increase the reliability of the process of assembling coaxial multicomponent three-dimensional structures by using industrial robots. Using this method in conjunction with a device to implement it makes it possible, given suitable time and labor expenditures, to assemble products with joints whose high-quality assembly either is impossible when conventional methods are used or else requires software, algorithms, and computers to control the process.

The method is based on redistributing the function of mobility during the assembly process between the robot and the assembly attachment. It entails having the first component secured immovably in the robot's working head and moving it in accordance with a program with three degrees of freedom to a device that attaches the first component with subsequent implementation of the

joining. Before the beginning of the making of each successive joint, the components are put into contact with one another along their edges and fastened, and the immovable first component is unfastened with the possibility of free linear movement in a plane perpendicular to the direction of the assembly force of the joint being made and free angular movement in space. When the joint is made, the first component is fastened in the resultant position. The connection between the working head and the component fastened to it is then removed, the next component is fastened to the robot's working head, and the process is repeated until the structure is fully assembled. Before each component of a multicomponent structure is joined, the first component is returned to the initial position and fastened.

Implementing the method assumes the following sequence and makeup of production interactions of the robot and the elements of the assembly attachment and the components being assembled. The component (18) (Figure 1b) is secured immovably in the robot's working volume, for example, on a cradle (not shown in the figure) of a disk (10) of the assembly device, and electromagnets (11) are switched on. The axis of the surface of the component's joint will occupy some initial position. After this, a component (17) is secured in the robot's (not shown in the figure) working head (16) and is then moved by the robot in accordance with a program with three degrees of freedom to the device that fastened the component (18). The components (17) and (18) are brought into contact with one another along their edges, after which one of the components (18) is unfastened by connecting the drive (14) of the clamp (6). the latter is moved upward, gliding along the outer surface of the casing (5). Under the effect of springs (8), a ring (12) unfastens a spherical bushing (9), thereby enabling the disk (10) with a component (18) located on it to effect a free linear movement in a plane perpendicular to the direction of the assembly (i.e., in the plane of the face of the casing (5)) and a free angular movement in space owing to mobility in the hinge. The joint is made, and under the effect of the assembly force, the component (18) assumes a position other than the initial position. When necessary, the components are fastened, for which an opening has been provided in the disk (10).

The component (18) in the position other than the initial position (Figure 1b, broken lines) is secured. The drive (14) is switched off, the clamp (6) (under the effect of a spring (13)) squeezes a ring (12) with a spherical surface to a spherical bushing (9). A force closure of the system clamp (6)-ring (12)-bushing (9)-ring (7)-casing (5) occurs. The component (18) is thus secured in the resultant position. Next, the working head (16) frees the process (17), the subsequent component (not shown in the figure) is secured in the head, and the process is repeated. Analogous actions are implemented until the structure is fully assembled.

Before each subsequent structure is assembled, the component (18) is returned to its initial position by connecting the drives (14) and (2) with an armature (1) to control an etalon (3). The latter, which is fixed relative to the casing (5) by a stopper ring (15), is moved upward along the inner surface of the casing (5), squeezing the spring (4), and comes into contact with the edge of the disk (10) at the beginning of its edge. Next, its centering band comes into contact with the disk's basing surface. The disk with the component (18) returns to the initial position. The drives (14) and (2) are switched on sequentially, thereby fastening all of the product's components in the initial position. The structure assembled in this manner is unfastened and removed from the device. The next component is mounted, and the assembly of the next structure continues.

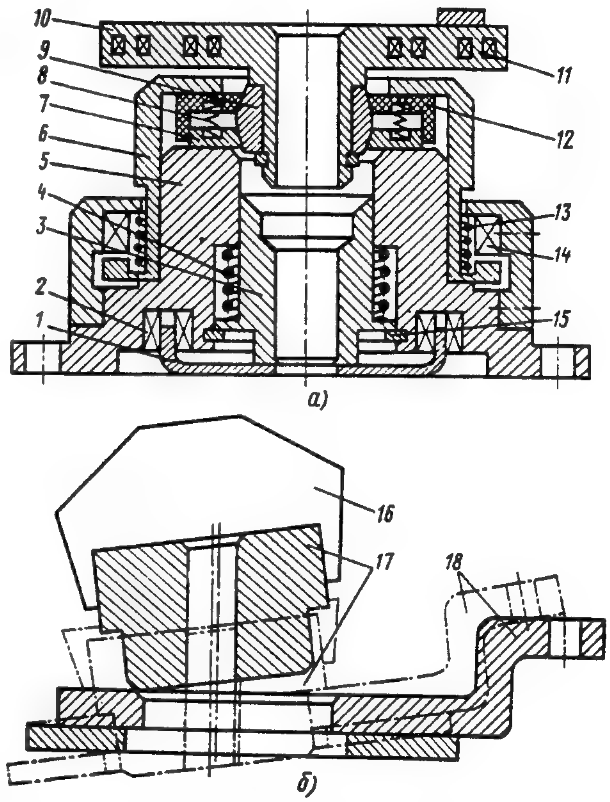

Figure 1

UDC 658.52.011.56.012.3.005;681.586;531.7.08.52

Postoperation Automatic Monitoring in FMS

907F0052C Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 12-14

[Article by N. Ya. Ilchenko, candidate of technical sciences, A. S. Mironenko]

[Text] Besides automating the main operations, introducing flexible manufacturing systems [FMS] assumes

increasing the quality of the products output (eliminating human participation in drawing conclusions regarding its suitability) by creating a monitoring system that is adequate from the standpoint of automation level, reliability, and capacity of the hardware for the production process of machining in an FMS. At the present time the laboriousness of monitoring the linear-angular dimensions and errors in arranging surfaces in components that have been machined reaches 20 percent of the total labor consumed on them. The automation level does not exceed 1 percent, which in and of itself has led to the urgency of work to automate and increase capacity during the implementation of monitoring operations.

Two types of monitoring that are not mutually exclusive but rather supplement each other and form a unified system are used in FMS. Built-in modeling of the individual and most strictly specific geometric parameters of a component ensures automatic retooling of equipment when a monitored parameter extends beyond the tolerance zone. Postoperation multiple-parameter monitoring based on measurement of a representative sampling of components and information processing makes it possible to draw a conclusion regarding the stability of the entire production process in an FMS and the acceptability of a lot of components. Depending on the nature and size of the deviations, its result either results in or eliminates the need to adjust all of the flexible manufacturing systems.

A system for postoperation automatic multiple-parameter monitoring of components operating as a component of a check post has been developed for machining FMS. Sixteen type 76503-02 measuring transducers with a measurement range of plus or minus 1 mm are used in the system as primary information sources. Components are loaded into the measurement system, which is used in two versions: for flange- or bushing-type components and for shaft- or axis-type components. Loading may be done either manually or by a type NTsTM-01 Elektronika robot. The range of component parameters measured is as follows: diameters of 10 to 80 mm and lengths of 40 to 200 mm for the shaft type and outer diameters of 10 to 100 mm, inner diameters of 20 to 80 mm, and heights of 5 to 150 mm for the bushing type. The following parameters are monitored: diameter, length, ovality, coaxiality, and radial run-out and end play. The measurement error amounts to 0.005 mm.

Figure 1 presents a block diagram of an automatic check post for multiple-parameter postoperation measurements. Besides a measurement system (1), the check post includes a readout and measurement electronic unit (2) with YeS5088 small floppy disk storages, a check post control unit (3), and an industrial robot (4) with its own control system. The readout and measurement electronic unit performs the functions of inputting/outputting measurement data and processing (including statistical) stored files of information extracted by the measurement transducers. The electronic unit has a built-in keyboard, thermal printer that records the monitoring result, and a display that displays the data entered, the monitoring results, and their statistical processing. The values of tolerances and deviations of the specimen component from the rated values are input into the electronic unit's memory from a keyboard, as are control programs, and the course of the process of the measurement results is controlled.

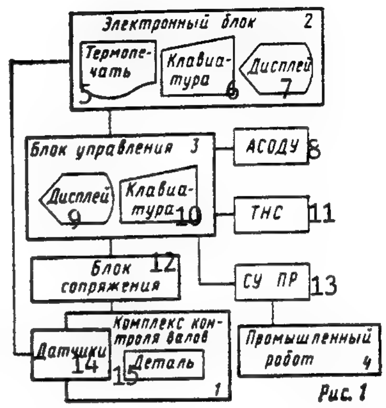

Figure 1.

Key: 1. Shaft-monitoring system 2. Electronic unit 3. Control unit 4. Industrial robot 5. Thermal printer 6. Keyboard 7. Display 8. Operational supervision 9. Display 10. Keyboard 11. Transport and storage control system 12. Interface unit 13. Industrial robot control system 14. Sensors 15. Component

A control unit based on a Neyron DZ-A14 computer controls the structural components of the check post-measuring system, electronic unit, and robot and switches off the check post when its work is finished or during a soft failure in operation.

The universality of the proposed technical monitoring equipment is achieved by a group monitoring technology and the capability of retooling by changing calipers, changing the monitoring program, and processing the results. The check post may be used both as a machine tool measurement system and in formulating FMS monitoring sections. Figure 2 presents the layout decision of a monitoring section that includes an Elektronika NTsTM-01-type industrial robot (3), a system (4) to monitor shafts, a system (8) to monitor bushings and flanges, and a control unit (5). A tray (6) with components is supplied by an automated transport and warehousing system that comprises a transport carriage (1) and exchange and storage devices, including a turning storage unit and exchange containers (7) and (9).

The high productivity of multiple-parameter monitoring of components (30 s to monitor one component from the standpoint of eight parameters) entering the section from five lathe machines of the FMS is provided by one check post.

The check post operations are programmed in BASIC, and the parameters with respect to development of the modes are specified by interaction from a keyboard or

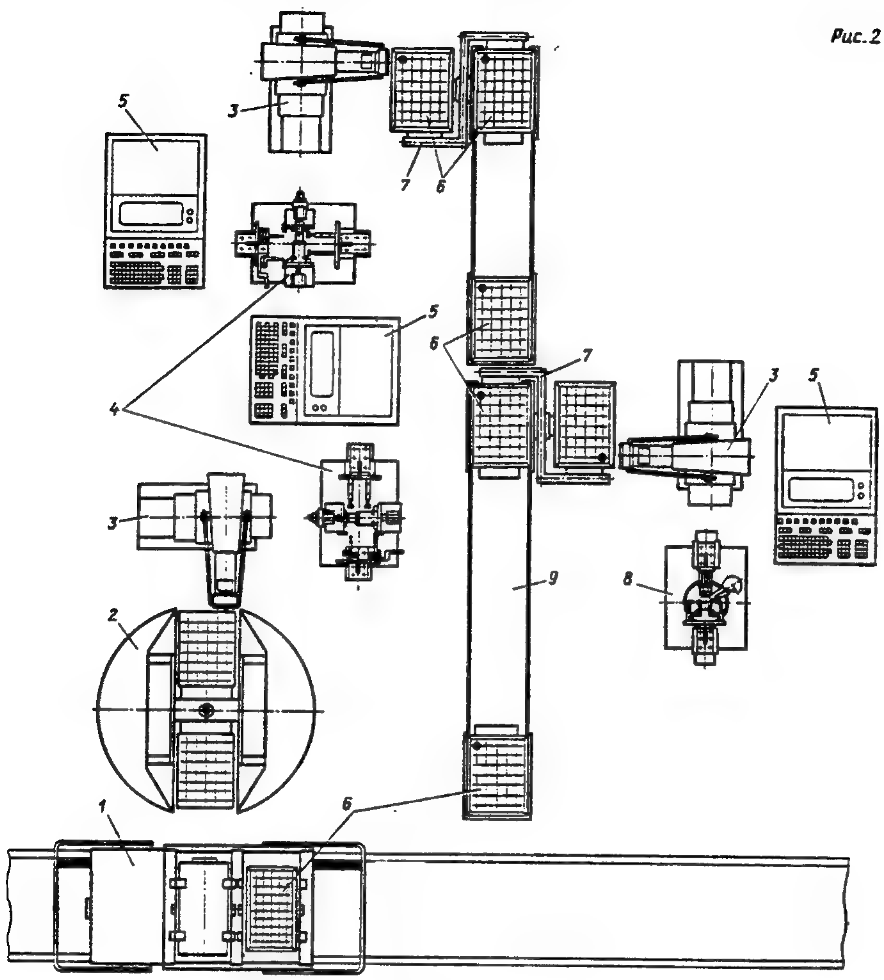

Figure 2

from YeS5088 floppy disk storage directly and the monitor's workstation. The check post control system provides for processing of the following principal operating modes: the control system links, daily-shift assignment and transport-storage equipment, alignment, and offline modes, which the operator selects from the program menu by a set of digital codes.

The control system links mode provides for operation in different versions of configuring the check post, i.e., with or without a robot, and in different versions of using the check post, i.e., with an automated transport system present and with an automatic link with an automatic operational supervision system present.

The second operating mode is implemented solely in the presence of a link with the operational supervision and ensures receipt of the daily-shift assignment, the structure of which contains information regarding the component code, operation number, order number, lot size, number of units on a tray, and a number of other pieces of data on the measurement system, including the attribute of the monitored lot. In addition, while operating in this mode the operator has the capability of changing the order of the components monitored or requesting (by using the instruction "bring") the next lot of the daily-shift assignment from the warehouse after having sent the component code to the transport and storage unit control system.

In the alignment mode variable data characterizing the check post's operation and the implementation of its individual functions are controlled. Upon entry into this mode, a videogram is output to the screen that includes the following submodes: input of data on mechanisms, input of data on the robot, debugging of the mechanisms, and debugging of the robot. The operator works out the required instructions on the basis of each of the positions of the videogram. Diagnostic messages are output in the alignment mode in the event that accident situations arise.

The last mode determines the check post's operation from the start knob on the basis of the installed algorithm without the operator's participation.

The production process monitoring subsystem in the FMS, which is implemented by using a check post based on multiple-parameter measurement systems and equipment for built-in active monitoring and diagnosis in the flexible manufacturing modules, is a structural component of the FMS automated management system. Figure 3 [not reproduced] presents a block diagram of the management of an integrated FMS that includes a production process monitoring subsystem. The diagram includes a group control system, equipment diagnostics, and component monitoring. From a functional standpoint, the production process monitoring subsystem tracks the technical status of the equipment and the quality of products in real-time.

Such an interpretation of the subsystem determines the structure of the information streams that are realized in the system developed in the direction from the production process monitoring subsystem and such automated enterprise management system subsystems as the automated process control system, operational supervision system, and automated system for the technological preparation of production. In this direction, by membership and request, information is sent regarding the equipment number, date of the monitoring measurements, sketch and operation number, component number, statistical data, a conclusion regarding the suitability of the lot monitored and the amount of defective production, and a message about failures and their causes. The information obtained, which will be analyzed by the automated enterprise management system, permits the taking of timely measures with regard to adjusting and repairing equipment, optimizing the machining modes and production process, and accomplishing other production tasks. The following are specific users of the information: the technological department, chief mechanic's department, manufacturing supervision department, and other management and planning services. At the present time, however, there are no systems providing practical use of this information.

Until recently primary attention in the development of production was focused directly on the problems of automating the machining of components. The growth rates of the technical level of equipment and organizational forms in this sphere have essentially determined the progress in the sphere of technical monitoring and the forms of its organization and metrological support. The importance of the information obtained in the production process monitoring system, its increased (at the level of automation increased) degree of reliability, and the comprehensiveness and well-foundedness of the selection of a monitoring method and hardware have, under the conditions of computer-integrated manufacturing, moved the solution of the problem of monitoring to the ranks of top-priority tasks.

The measurement system developed made it possible, by using software and algorithms, to compensate for errors of the skewing and shifting of the axis of a component when it is configured relative to the axis of the base nodes of the measurement system.

UDC 621.865.8-113:621.757.06

Assembly Robotic Production Process System

907F0052D Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 14

[Article by I. S. Khomak]

[Text] The robotic production-process system created on the basis of two model PR5-2E industrial robots is intended for assembling a metal axis 3 to 5 mm in diameter, 20 to 45 mm long, and with bushings 20 to 50 mm in diameter and 2 to 4 mm thick (the flywheel of the inertial mechanism of a child's toy consisting of an axis and two disks) by the method of sinking the metal of the bushing in the pressing site.

Two industrial robots (1) and (13) equipped with gripping devices (15) and (12), a lever press (7), a die (14), a chute-cutoff device (8), a gate feeder (4) with a chute (5), and a post (3) with a sensor and a scrap chute (16) are mounted on a T-shaped table (2). Universal posts with vibrating bins (6) and (9) whose position may be controlled in the horizontal and vertical planes are attached to the table on vibrating supports.

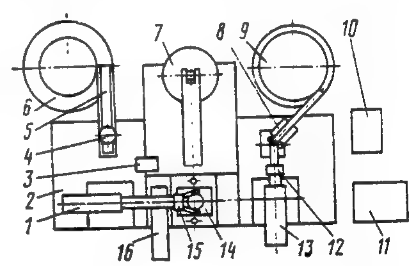

Figure 1

Inside the T-shaped table are pneumatic equipment and a device to check for the presence of a component in the vacuum grip device (12). Alongside the T-shaped table there is a control member (11) consisting of an MKP-1-32-05 programmable microcontroller, a power supply unit, and a control unit along with a unit to pump air out (10) that is based on a 2NVR-5D vacuum impeller pump, a receiver, and a vacuum gauge.

The components being assembled (disks and axes) are loaded into the vibrating bins in a heap. The axes pass from the vibrating bin (9) to the tube of the chute-cutoff device, which is a storage unit. From there they are issued one by one in a vertical position to the gripper's position. Two sequentially activated electromagnets, which act as gate-cutoffs, are used for this piece-by-piece issuing. The industrial robot's (13) gripping device selects an axis, and the robot's arm turns 90 degrees, stretches out, drops, places the axis into the die, and returns to its initial position.

At the same time, disks pass from the vibrating bin (6) along a chute (5) to the gate feeder's storage unit. The gate issues them in pairs to the gripper's position. The robot's (1) mechanical gripping device (1) selects two disks, turns 90 degrees with them, and extends, drops, and places them in a spring-loaded orienting table, thereby putting them on the end of the axis that has been mounted in the die. Next, the arm of the gripping device moves out from under the press. A lever press presses the disks, after which the orienting table with the finished product returns to the upper position. The robot's (1) arm extends and takes the product from the die. Upon returning to the initial position, it releases the product into a chute (16) from where it passes to a tray.

All of the movable components of the robotic production-process system, with the exception of the gate feeder, are equipped with transducers to monitor the end positions. The presence of disks in the mechanical gripper is checked by a KVP-16 contactless sensor located on a post (3), and the presence of an axis in the vacuum grip is checked by an electrical compound pressure and vacuum gauge located on a pneumatic panel inside the T-shaped table. During operation in an automatic mode, the absence of a signal from any of these sensors shuts the robotic production-process system down.

The control member enables the robotic production-process system to operate in automatic, step, and manual modes. The manual and step modes are used during alignment operations.

Programs are input by an MKP-2-32-05 programmable microcontroller.

Lamps on the control unit's face panel are intended to indicate the malfunction of mechanisms in the event of a system operating failure.

The robotic production-process system has a capacity of 8 assemblies per minute and a power consumption of 0.8 kW. Depending on the type of pressing, the force developed by the lever press amounts to 12 or 16 kN, with plunger courses of 55 and 45 mm, respectively.

UDC 62-231.223

Rolling and Sliding in Screw-Type Ball Mechanisms

907F0052E Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 15-16

[Article by I. B. Shenderov, candidate of technical sciences]

[Text] Screw-type ball mechanisms, which have ease of movement, high k_{eff} values, and high precisions of movement, are hard to replace in precision machine tool and machine building despite the complexity of their design and manufacturing technology. The theory of screw-type ball mechanisms is rather well developed; nevertheless, the general machine building literature includes imprecise descriptions of the mechanisms, particularly in that portion of the literature devoted to calculating their k_{eff}. It is assumed that screw-type ball mechanisms differ from skew-slide nut gearings in that the sliding friction is replaced by rolling friction, and a formula has been proposed for calculating the mechanisms' k_{eff} that is analogous to formulas from calculations of conventional skew gearings. The discrepancy between such a theory and practice is quickly becoming manifested in recommendations calling for the use (in calculations) of coefficients of resistance to rolling that are incomparably larger than in the case of rolling, let us say, in ball bearings.

Specific design of drives with screw-type ball mechanisms requires a clearer understanding of the distinctive features of the operation of these mechanisms.

Figure 1 is a diagram of a screw-type ball mechanism with a semicircular thread profile. The numbers in the figure indicate the following: 1, screw; 2, nut; 3, balls, α, contact angle in the thread's normal cross section; λ, the thread's helix angle in the mean diameter (the diameter of the location of the balls' centers); r, the balls' radius; R, the radius of the circumference of the contact of the balls and nut; v_B, screw velocity; ω_r, angular velocity of the nut's rotation; v and v_r, linear velocities of the center of the ball and the points of the nut that are in contact with the ball; and C_1 and C_2, the points of contact between the ball and the screw and nut. For the specificity's sake, it is assumed that the nut rotates whereas the screw, which is loaded by the downward force, moves upward.

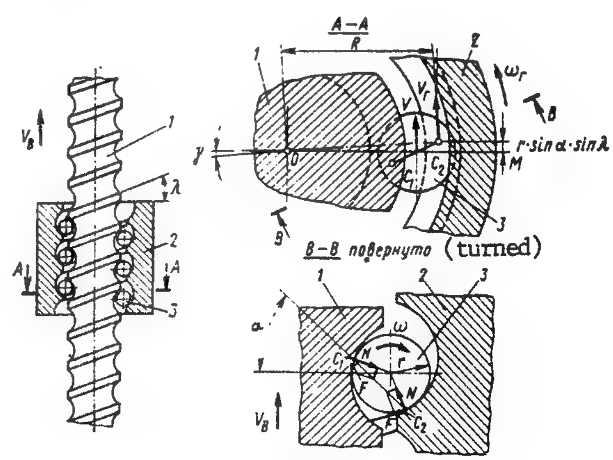

Figure 1

It is obvious that the line C_1C_2 of contact between the ball and screw surfaces of the screw and nut channels does not lie on the radial plane of the mechanism passing through its longitudinal axis. In the cross section A-A the projection of the line C_1C_2 forms some angle γ with the radius OM (O being the projection of the screw's axis), and $\sin \gamma = r/R \sin \alpha \sin \lambda$. When the nut rotates, the balls move such that their centers in the projection A-A

remain on a circumference with a constant radius. Consequently, the projection of the velocity v is directed perpendicular to OM. The velocity of the point C_2 on the nut, which interacts with the ball, is perpendicular to the radius OC_2 and forms the angle γ with the projection v. The velocity of the point C_1 on the screw is perpendicular to the plane A-A.

The specified three velocity vectors are linearly independent of one another. One consequence of this is the characteristic distinction of screw-type ball mechanisms: the balls rotate around the axis coinciding with the direction of the motion of their centers, and a transverse slide occurs in the contact. In fact, upon any motion of the sphere, the velocity of its center equals the half-sum of the velocities of the diametrally opposed points of its surface, in particular, that of the points lying in the contact areas C_1 and C_2. The velocity v of the ball's center, owing to its linear independence, cannot be the half-sum of the velocities v_B and V_r; therefore, the velocities of the points C_1 and C_2 of the screw and nut do not coincide with the velocities of the points on the ball that interact with them. The magnitude of the sliding is proportional to the projection of the velocity v_r on the line OM.

If there is no sliding between the ball and screw (here the coefficient of sliding friction is larger), in the contact of the ball with the nut the slide velocity equals either $v_r \sin\gamma / \sin\alpha$ or $\omega r \sin\lambda$. If there is no sliding of the ball relative to the nut, sliding is present in the contact between the ball and screw—and with the same relative velocity. Finally, if the friction conditions in both contacts are identical, the ball rotates in a plane transverse to the direction of the motion of its center with an angular velocity of $\omega = \omega_r/2\sin\lambda$, and sliding with the velocity ωr is observed in both contacts. The friction forces F arising in the process shift the ball's center as is evident in Figure 1 in the cross section B-B. N indicates the normal force in the contact. The direction of the rotation ω of the balls and their shift in the thread change when the direction of the nut's rotation changes.

As a result of the shifting of the balls under the effect of the friction forces, there is a danger of movement out of the contact areas to the edge of the thread and a reduction in the mechanism's efficiency. To avoid this, the following conditions must be met when designing reversible mechanisms:

$$[(R_5 - R_3)/R_1]\,[1 - \cos(\alpha + \rho)] \text{ and}$$

$$[(R_4 - R_6)/R_2]\,[1 - \cos(\alpha + \rho)],$$

where ρ is the friction angle, $tg\,\rho = f$, f is the coefficient of sliding friction, R_1 and R_2 are the radii of the thread profiles of the screw and nut, R_3 and R_5 are the inner and outer radii of the screw's thread, and R_4 and R_5 are the outer and inner radii of the nut's thread.

The k_{eff} of the screw-type ball mechanism is primarily determined by the losses to friction when the balls slide in a transverse direction. The strength of the friction forces acting on the contact of one ball with a screw and nut is calculated as the doubled (two contacts) product of the friction forces by the sliding velocity:

$$\Delta A = F\,\omega_r \sin\lambda.$$

At the same time, the contribution of one ball to completion of the useful work, i.e., lifting the load, equals the product of the axial component of the normal force times the velocity of the screw.

$$A = N \sin \alpha\omega_r R\, tg\,\lambda.$$

Consequently, the coefficient of the losses equals ν is approximately $\Delta A/A = f_r/(R \sin\alpha)$, and the mechanism's k_{eff} amounts to $\eta = 1 - \nu = 1 - [f_r/(R \sin\alpha)]$.

For a 40 x 10 OST 2N23-7 gearing when f = 0.1, r = 3 mm, R = 22.1 mm, and α = 45 degrees, we obtain η = 0.98. The high k_{eff} is explained by the low transverse slide velocity. In the given case, when $\omega_r = 10\ s^{-1}$ and λ = 4.55 degrees, the slide velocity amounts to 1.2 mm/s or 1.1 percent of the speed of the balls' centers.

Besides rotation around the axis coinciding with the direction of the motion, the mechanism's ball rotates (with an angular velocity equal to $\omega_r/2 \sin\alpha \cos\lambda$) around the contact line C_1C_2. This rotating, which is caused by the extent of the real contact areas in a radial direction, causes additional losses to friction; however, they are significantly less than the losses to friction in the event of lateral rotation of the ball. The energy losses when the ball rolls in a plane with the trail C_1C_2 are even smaller. Its position is such that, despite the fact that rolling predominates in screw-type ball mechanisms, the main energy losses and wear in them are caused by the sliding of the balls in contact with a screw and nut. Compared with that in a skew-slide nut gearing, the sliding velocities in the connections are reduced by a factor of $2R/(r \sin 2\lambda)$, which explains the high operating characteristics of screw-type ball mechanisms.

When designing and manufacturing screw-type ball mechanisms, a correct understanding of the kinematics and sources of these mechanisms' resistance to motion will facilitate an increase in the efficiency of the new developments.

UDC
658.52.011.56.912.3.005; 658.563.011.56; 621.9.02.539

Tool Support for FMS

907F0052F Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 14

[Article by V. A. Nesterov, A. V. Baykov]

[Text] The plan (its technical organization portion) for a section to adjust a tool outside a flexible manufacturing system [FMS] (flexible automated line) for machining

reducing gear casings has been developed at the Donetsk Planning, Design and Technological Institute.

The section is a structural component of an automated tool support system and performs the following tasks:

ordering and obtaining a tool from a central tool warehouse;

storing and taking stock of tools;

assembling, adjusting, and making up sets for a tool adjustment in accordance with a set completion chart;

disassembling an adjustment that has already been used;

input and ongoing monitoring of a tool's quality and precision;

sending a tool for sharpening and repair;

inventorying a tool;

sending information to the control computer complex regarding a tool's motion and furnishing workstations with tools.

The annual and monthly requirements of a flexible automated line for cutting, auxiliary, and measurement tools is calculated on the basis of the scheduling program for manufacturing components. These data are the source data used when calculating the number of instruments for adjusting a tool outside a machine tool, the number of those working in a section, and the makeup and amount of mechanized auxiliaries.

From an organizational standpoint, the section consists of four structural subdivisions: a section to store and make up sets of tools, a tool assembly-disassembly and adjustment section, a checkpoint, and a storage unit for adjusted tool sets (the latter are necessary owing to the lack of a link with the automated transport and warehousing system owing to the configurational features of the flexible automated line).

The section's workers are joined into one brigade. The flexible distribution of functional duties between brigade members, i.e., the combination of occupations and interchangeability of workers in the event of an unforeseen situation, is assumed.

To achieve failure-free operation of the tools' adjustments, the compulsory changing of a tool has been introduced after the period of its guaranteed durability (which is calculated with an allowance for the probabilistic nature of wear at a reliability level of 0.9) has elapsed. The storage norms for a cutting tool in the section eliminate downtime of the flexible automated line.

Information and material links between the section and the flexible manufacturing system's functional support and the plant's subdivisions are presented in the plan.

The anticipated yearly economic effect from introducing the plan amounts to 15,000 rubles.

UDC 621.9.06-83

New Structure for Machine Tool Drive

907F0052G Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 30-32

[Article by V. M. Pestunov, candidate of technical sciences]

[Text] The block diagram of the machine tool drive awarded author's certificate No 844209 offers extensive possibilities for resolving the contradiction "load-precision." The invention's purpose is to improve the operating conditions of the mechanisms and actuators that determine the machine tool's output characteristics and its production capabilities. This result is achieved by installing a differential mechanism (whose outlets are connected to the actuators) in one of the drive's kinematic chains.

When the drive is operating, the electric motors (1), (2), and (3) (Figure 1) transmits motion along the kinematic chains of the tie through the adjustment links (4), (5), and (6) to the actuators (7), (8), and (9). At the same time the motion is also fed to a differential mechanism (10) that is, for example, implemented in the form of a planetary gearing with the number of degrees at the outlet based on the number of kinematic circuits involved in producing the complex shape-forming motion. As a result, the force effect of not one but two kinematic chains of the drive (which also receive its production load) is exerted on the machine tool's actuator (8). The kinematic chain feeding the actuator (8) exerts the force P_2, and the differential mechanism exerts the force P_1.

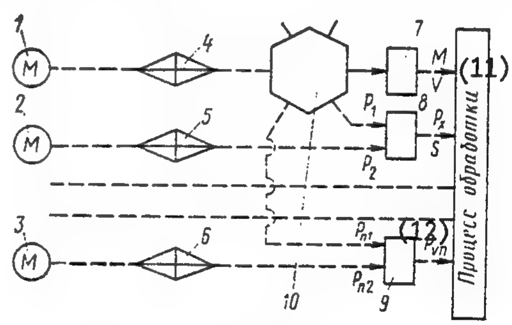

Figure 1

Key: 11. Machining process 12. $P_{control}$

Because the specified forces receive the production load and the forces of the actuator's resistance to movement, the feed mechanism only receives a portion of the load. The magnitude of the latter is determined by the parameters of the differential mechanism (10) and may be any amount before the specified amount, i.e., corresponding to the optimum value for the conditions of the drive's functioning.

An analogous effect occurs with the machine tool's other actuators. Thus, during the specified machining process modes, the loads of the kinematic chains may be redistributed in any ratio before the specified one. This makes it possible to create conditions for the optimum functioning of the kinematic chains and mechanisms, which largely determine the machine tool's output characteristics, and to combine the conditions for their optimum operation with the optimum parameters of the machining process. At the same time, however, there is an increase in the load of the main drive, for example. However, since the drive (in this case the main drive) relieves the other kinematic chains, it has relatively smaller losses when transmitting power, and the total losses in the machine tool are reduced.

The block diagram under examination is a generalization and encompasses the main trends in the development of the structure of a machine tool drive. Standard circuit designs of such a drive are examined below.

A device based on author's certificate No 729030 solves the problem of simplifying the drive's design and reducing its overall dimensions and mass. The rotation is transmitted from the electric drive (1) (Figure 1) through a splined joint (2) to a spindle (3) that is mounted on bearings in the tail spindle (4) (the latter being connected to the frame (5) by a self-locking thread). When the spindle and drive ring (6) (which has a complex profile) of the vibrator rotate, the vibrations are transmitted to the driven ring (8) through a spring, with the frequency and amplitude of the vibrations being determined by the parameters of the profile of the drive ring and the spindle's rotation frequency.

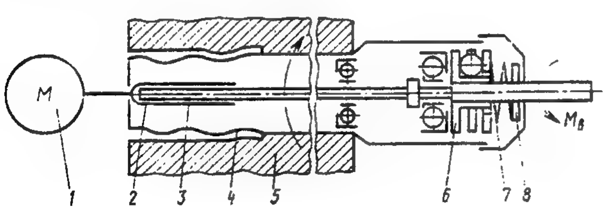

Figure 2

Tests conducted on the device (during a drilling process) showed that it crushes overflow chips reliably and possesses adaptive properties. As the strength of the material being machined increases, the magnitude of the feed, like the tool's axial movement to turn the spindle, is reduced. This makes it possible to stabilize the load on the tool.

By changing the forces of the spring (7) it is possible to control the extent of the feed smoothly over a wide range.

A special spindle node solves the problem of relieving the tail spindle guides and increasing the precision reliability. The tool is mounted in its spindle (1) (Figure 3) with a screw shank. The spindle is mounted in the tail spindle (2). The tail spindle is kept from turning in the frame by a key (3) on which the roller pusher (4) of the feed mechanism has been mounted. The spindle's screw shank is connected by a non-self-locking thread to a bushing (6) that is in turn connected with the main drive (not shown in the figure).

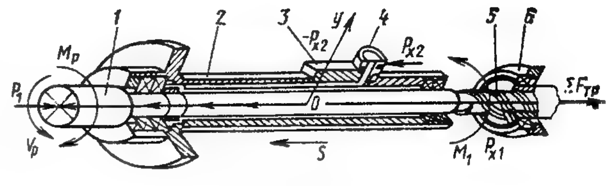

Figure 3

During the operation process, the main motion v_p and longitudinal feed s are communicated to the spindle. The production load (the torque M_p and the axial force P_1) is received by the main drive M_1 and the feed drive P_{x2}. When the torque is transmitted by the non-self-locking screw pair shank-bushing, which has the direction of the screw line, which is in turn the opposite of the spindle's rotation, the axial force P_{x1} (which is directed counter to the production load P_1) arises in it. As a result, the tail spindle is in equilibrium under the effect of the forces

$$P_1 = \Sigma F_{frict} = P_{x1} + P_{x2},$$

where ΣF_{frict} is the sum of the friction forces in the forward-moving kinematic pairs.

It follows from the relationship presented that the forces of the feed's resistance to motion are received not only by the feed mechanism (P_{x2}) but also by the skew gearing (P_{x1}) of the main drive. The force (P_{x1}) is applied along the spindle's axis and coincides in direction with the production load (P_1). This creates favorable conditions for loading the tail spindle guides since the relationship of the forces P_{x1} and P_{x2} is determined by the slope of the screw pair and may be optimum with respect to the wear and reliability criteria of the guides.

The comparative tests of the proposed spindle node versus a conventional mechanism that have been presented showed that complete relief of the feed drive reduces the rate of the loss in the drive's precision four- to fivefold when compared with a conventional loading circuit.

The problem of relieving the guides and increasing their precision reliability is solved by a design circuit for multiple-spindle "building-block" machines (author's certificate No. 1017469).

The drive is mounted on a bed (1) (Figure 4). During the machine tool's operation, the spindles (13), (14), (15), (16), and (17) receive their rotation from an electric drive (3) through replaceable wheels (5), a transfer gear box (4), adjustment links (6), (7), and (8), and skew gearings (11), (10), and (9). Each of the skew gearings (9), (10), and (11) is autonomously connected with at least

one spindle. At the same time, the power table communicates a reciprocating motion to the spindle box (12) in accordance with the machine tool's operating cycle.

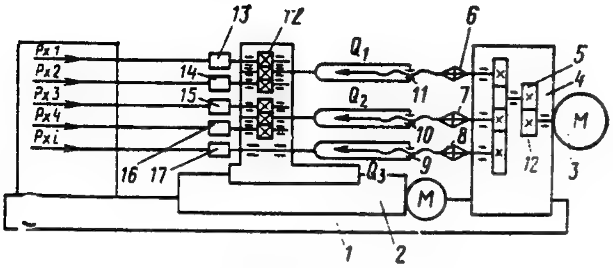

Figure 4

During the machining process when the skew gearings (11), (10), and (9) transmit a torque, axial forces Q_1, Q_2, and Q_3 that are directed opposite to the direction of the axial components of the cutting forces P_{x1} through P_{xi} arise in them. The driven elements of the skew gearings on the plane of the spindle box are arranged in the form of a triangle with a design such that it is possible to control the elastic displacements of the spindle box loaded by the axial components of the cutting forces P_{x1} and P_{xi}. The magnitude and application point of the equal-acting relieving forces change as the slope in the skew gearings (9), (10), and (11) change.

Using the proposed drive makes it possible to control the elastic deformations of the elements of the system machine tool-attachment-tool-component by changing the position of the point at which the equal-acting relieving forces are applied.

The drive based on author's certificate No 916243 solves the problem of controlling the elastic deformation of a multiple-spindle box. The frame (2) (Figure 5) of the spindle box is mounted on a base (1) connected with the feed mechanism. During the process of the machine tool's operation, the spindles (6), (7), (8), (9), (10), and (11) receive the production load, the torque, and the axial forces P_{x1} through P_{x6}. At the same time, when the torque is transmitted through non-self-locking skew gearings (3), (4), and (5), axial forces Q_1, Q_2, and Q_3 arise in the latter. Moreover, the motive force P_π of the feed mechanism's power table acts in this same direction. The gear ratio of the links adjusting the main drive's kinematic chain (not shown in the figure) are selected such that the forces Q_1, Q_2, and Q_3 balance the external load on the spindles (6), (7), (8), (9), (10), and (11). This makes it possible to eliminate the elastic deformation of the spindle box, reduce its mass, and increase the precision with which blanks are machined.

The task of increasing the capacity of the machining process while simultaneously reducing the wear of the guides is solved by the design scheme of a drive for a drilling machine.

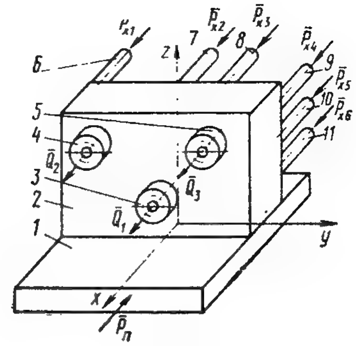

Figure 5

During the process of operation on this machine tool, the workpiece (4) (Figure 6) mounted in the spindle chuck (5) is rotated at the speed of the main drive. A vibrator (1) communicates axial vibrations to the tool (3). Under the effect of the force of the weight of the movable subassemblies and components, the main drive (electric drive (9)-speed gear box (8)-spindle (5)) moves in the direction of the drill, with the choke (11) restricting the maximum allowable velocity of this motion. As soon as the workpiece touches the tool, the axial component of the cutting force (which exceeds the motive force) stops it. Upon movement upward, the vibrator, which communicates the axial vibrations to the tool, makes the tool cut into the workpiece at an amount equal to the amplitude of the vibrations. At this time reverse motion of the main drive along the guides (7) is excluded by a check valve (12) that locks the hydraulic cylinder's end (6) with a piston (10). The tool cuts out a layer of metal on the rotating blank to the depth of the next incision (the cutting process is implemented only when the blank is rotating without any feed motion).

When the tool moves down in accordance with the vibrator's axial vibrations, the workpiece is released. Then, once again the main drive moves along the guides until the workpiece touches the tool. At the same time the valve (12) is released. Then, when the tool moves up, the vibratory machining cycle is repeated.

It is known that the extent of the wear $v = kPv$, where K is the coefficient, P is the pressure on the surface, and v is the velocity of the relative slide of the wear surfaces. It should hence be noted that the extent of the wear equals zero when $v = 0$ and $P = 0$. Therefore, to obtain an operating mode for the guides of $v = 0$, the process of the drive that effects the machine tool's working motion is divided into two stages: in the first, movement is implemented when the production load is close to zero and the wear of the guides will also be close to zero.

In the second stage of discrete movement, the drive stops ($y = 0$), and the tool cuts into the blank owing to the vibrator's motion. Since the velocity of the relative motion of the guides equals zero, their wear also equals zero. This machining method creates a more favorable operating mode for the guides since in each stage of the

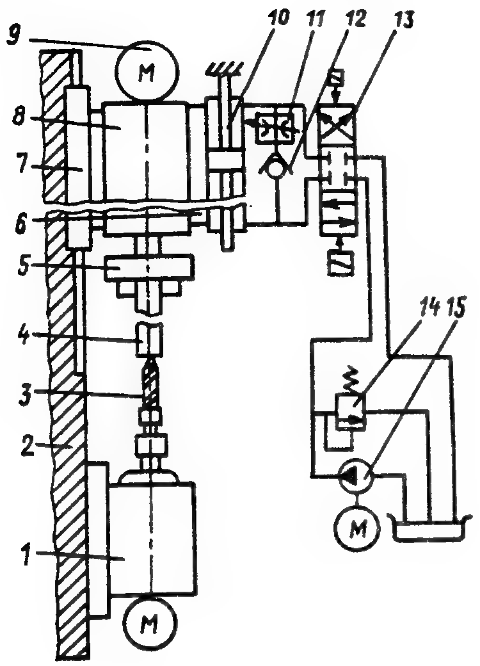

Figure 6

discrete movements the extent of the wear is close to zero. Thus, the condition of zero wear of the guides is maintained only under the condition that the amplitude of the vibrations exceeds the feed; in the opposite case, on the other hand, the drive's discrete movements will be implemented under a load.

To effect idling and adjusting movements, the machine tool's main drive is equipped with an individual hydraulic drive that turns on the pump (15), valve (14), and distributor (13). When oil is fed under pressure to one of the spaces of the hydraulic cylinder, there is a quick steadying movement of the drive up or down along the bed's guides (7). The distributor is controlled by path automation equipment. A system of weights installed in the main drive and a balancing system (not shown in the figure) is used to change the magnitude of the motive force. The frequency and amplitude of the tool's vibrations are changed by adjusting the vibrator in accordance with the key vibratory machining parameters and the rigidity of the system machine tool-attachment-tool-component.

The proposed machine tool may be used for drilling with a rotating tool or with simultaneous rotation of the tool and blank, as well as for drilling hard-to-work materials. Tests showed that drilling "downward" makes it possible to reduce the torque in the tool during the deep drilling of cast iron to a half and during the drilling of steel to a third.

The problem of increasing precision and expanding technological capabilities is solved by the design scheme based on author's certificate 867526.

The drive contains an electric motor (1) (Figure 7), an adjustment link (2) for the main drive that is controlled on the basis of the gear ratio, a differential mechanism (5), a feed drive actuator (support) (6), a link adjusting the feed drive (3), a mechanism (4) converting the rotary motion into a forward motion, a transducer (10), a comparator (8), a control point-setting device (9), and an amplifier (7).

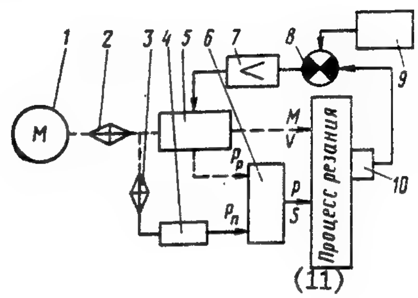

Figure 7

Key: 11. Cutting process

During the process of the drive's operation, machining occurs with the cutting speed v and feed s. The production load M and P arises in the drive-spindle actuators and support. This load deforms the elements of the machine tool's production system, including the guides. This deformation is measured by a transducer (10) that is included in the system to automatically control the gear ratio of the differential mechanism, which includes a control point-setting device (9), comparator (8), and amplifier (7). As a result, the differential mechanism's gear ratio is changed. It in turn changes the ratio of the forces P_p and P_n, which, given the specified modes, provides the best conditions for loading the machine tool's actuator and the maximum increase in machining precision.

The machine tool drive based on author's certificate No 674863 solves the problem of increasing precision and reducing losses to friction. The drive contains the kinematic chain of the main motion, which includes an electric motor M (Figure 8), an adjustment link i, and a differential mechanism D. The latter is kinematically linked with the actuators (1), (2), ..., n of the kinematic chains of the longitudinal, transverse, and vertical feeds, which contain the actuating motors M_2 through M_n included in the NC system.

During the process of the machine tool's operation, the kinematic chains of the shape-forming motion provide the main motion, which determines the cutting speed v, whereas the kinematic chains of the feed provide motion with the specified feed velocity (s_1, s_2, ..., s_n). The actuators are under the effect of the production load (M, P'_1, P'_2, ..., P'_n). This makes it possible to relieve the kinematic chain of the feed by a kinematic link with the differential mechanism. The kinematic links of the feed and their elements make it possible to increase the precision and the precision reliability of the drive.

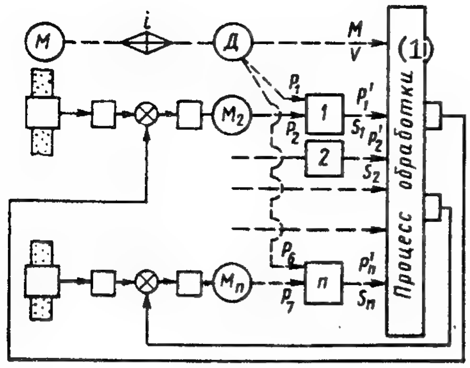

Figure 8

Key: 1. Machining process

UDC 621.771.6.06.-229.6/.8

Loading-Unloading Device

907F0052H Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 32-33

[Article by I. A. Demin]

[Text] The Mariupol department of the Zaporozhye scientific production association NIKTIMselkhozmash [Scientific Research and Technological and Design Institute of Agricultural Machine Building] has developed a device for the Agricultural Machinery Plant imeni the October Revolution (Odessa). The device (patent request No 4312486) feeds disk blanks with a central hole to a machine tool's machining zone to mill blades and removes the finished components to a tray.

The part of the feeding chute adjacent to the machining zone is detachable. This made the device simpler to design and made it possible to reduce the slope of the chutes to a minimum since a common rolling zone located at the zone in which components are machined was formed for the two chutes. As a result, the operating conditions were improved, and the overall dimensions of the device were reduced.

The loading-unloading device contains a frame (1) on which is mounted a gravity feed chute consisting of a stationary section (2) and a removable section (6). The outlet part of the removable section is intended for placing components (3) on the machine tool's (8) radial support (7).

Pins (19) have been mounted on the machine tool's bed for removing the machined components from the centering conical arbor (16). The removable section has movable side walls (11) and (12) that are mounted on guides (5) and that culminate in the machining zone with jaws (17) and (18). A power cylinder (15) moves the side walls. Stops (10) and (13) serve to limit their movements. A protrusion (20) of the side wall (12) forms the bottom of the removable section of the feed chute.

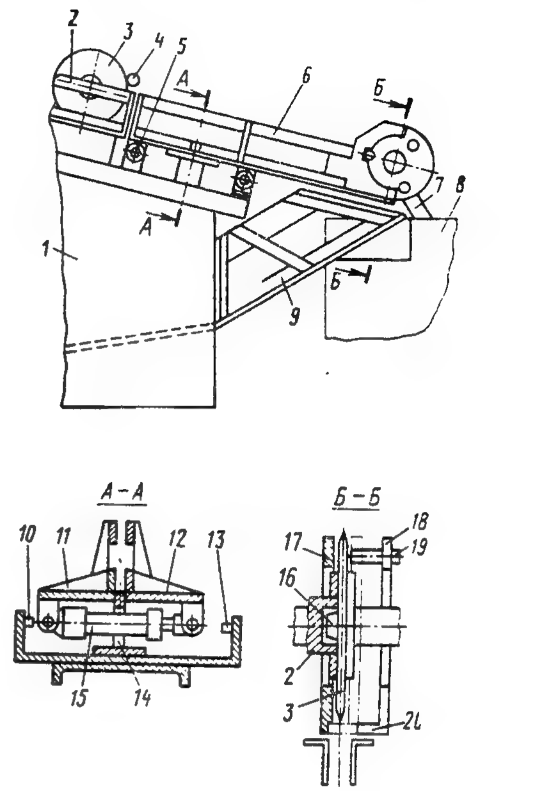

Figure 1

In the initial position the side walls of the chute's removable section are reduced and are thrust into a longitudinal stop (14). The width between the walls equals the trough width of the chute's stationary section.

Upon an instruction from the machine tool, the mechanism for piece-by-piece issue (4) lets a component pass. The component rolls into the machining zone and is thrust into the radial support (7). An instruction is sent to secure the component with a clamp, the component is set into rotation, and at the same time the hydraulic cylinder parts the side walls of the chute. Wall (11) is moved 5 mm from the component, and wall (12) is moved 20 mm from the component. This opens a passage for withdrawing the chute (9). After the machining has been completed, the component is released, and pins (19) are used to remove it from the conical arbor. With its vertical position preserved, it falls into the exit chute.

Next follows an instruction to move the side walls to the initial position. The cycle is repeated.

The diameter of the disks moved ranges from 400 to 510 mm, and they are 4 to 6 mm thick.

The overall dimensions of the installation are 1,700 x 800 x 1,400 mm. Its mass is 320 kg.

The proposed economic effect from introducing the device amounts to 700 rubles yearly.

UDC 621.869.88

Containers

907F0052I Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 33

[Article by N. N. Rakhmanov, meritorious inventor of the UkSSR]

[Text] The open-top frame of a container (author's certificate No 1344690) for storing and transporting loads has walls (2) (Figure 1) and a base (1). Between the movable bottom (4) and base of the frame are levers (5) and (6) in the form of Π-shaped frames of an elastic bar material. The frame width of the lever (5) is greater than that of the frame of lever (6), which makes it possible to arrange them in a crossed manner. The frames' cross bars are mounted in the grooves of guide strips (3) perpendicular to the bottom and are capable of moving in them. The frame levers are secured to the container's base on hinges (7) and (8), and their heat-treated ends (which jut out of the hinges) are bent back and mounted with the capability of thrusting into the base.

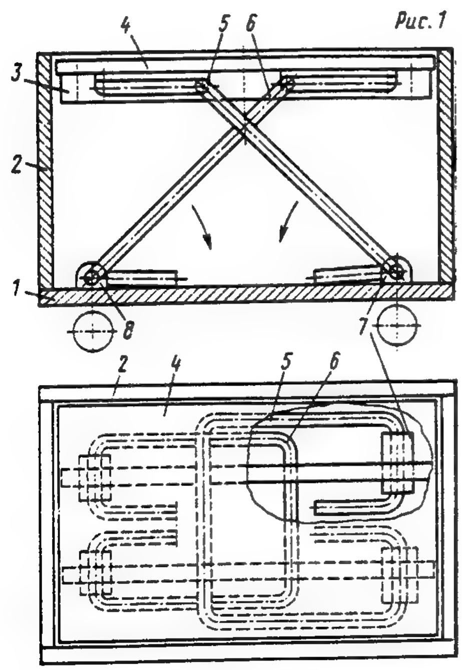

Figure 1

As the container is loaded, the movable bottom is lowered, turning the levers' frames in the hinges on the base. The cross bars of the Π-shaped frames are located lengthwise in the guide strips' through grooves. During turning, the levers are twisted in the direction indicated by the arrows so that their bent-back ends are thrust into the container's base. As a result, potential energy is stored in the levers' bent ends, which fulfill the function of torsion bars, and the dynamic load is damped at the same time.

As the unloading proceeds, the movable bottom moves upward under the effect of the stored potential energy, thereby ensuring a constant level when products are unloaded from the container.

The container may be used as a storage unit for blanks in machining shops. Its simplified design makes it possible to increase its operating reliability.

The container for piece cargo (author's certificate No 1400965) has high cushioning properties.

Elastic elements (6) are mounted in its frame (2) (Figure 2), which has double walls and a double bottom. The inner walls (9) and bottom (3) are not attached and are capable of moving. Its stay wedges (5), (7), and (8) are located in space between double walls and a double bottom and interact as sloped faces. The container has a removable cover (11). The position of the edge wedge elements (4) is fixed by supports (1) and a carcass frame (10), on which the inner walls rest. The wedge elements (5) and (7) are attached to rubber elements, and the elements (4) and (8) are mounted freely. To reduce the mass, the wedge elements are manufactured hollow or else are made of plastic.

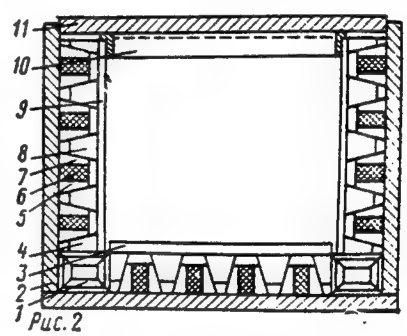

Figure 2

During the process of the transport of the piece cargo, under the effect of the dynamic load, the bottom and one of the side walls are moved down. The wedge elements (8) and wedges (5) and (7) move and deform the elastic elements. The transported cargo is cushioned and protected against damage during transport.

Thanks to the friction between the wedges' surfaces and the frame walls, vibrations and a portion of the energy are damped, which increases the device's cushioning properties. This is especially important when transporting precision equipment, such as that for robots and manipulators and instruments for ATS [not identifiable from context].

UDC 621.874-254

Wheel With Elastic Flanges

907F0052J Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 33-34

[Article by S. L. Panov, candidate of technical sciences, and A. V. Kryuchkov]

[Text] Just how many difficulties are entailed in repairing an overhead traveling crane is known at every enterprise. The cause for repair is often wear to the crane's wheel flanges due to the asymmetrical application of the load, the lack of parallelism and differences in heights of the crane path's rails, the asynchronism of the brakes' activation, a lack of coincidence between the rotation frequencies of the electric motors of the mechanism that moves the crane (in the case of a design with an individual drive), etc.

Cranes are regularly stopped (from one to four times a year) to change wheels.

A crane wheel (author's certificate No 929532) has been developed at Kiev Polytechnic Institute and makes it possible to extend the service life of flanges and make the operation of replacing them easier. The wheel contains a hub (1) (Figure 1a), disk (2), and rim (3). Packets of flanges are mounted in the annular channels (4) of the rim. Each packet consists of an elastic (5) and a rigid (7) flange. The flange packets are mounted immovably in the rim by bolts (8). The elastic flange (Figure 1b), which is made of spring steel to increase its flexibility, is in the form of a thin annular disk with radial slits and openings under the bolts.

In the event that the flanges roll onto the rail head, the elastic rib and rubber ring are deformed. The magnitude of the normal component of the force of the rail's pressure on the flange turns out to be much smaller than in the case of a conventional "stiff" flange. The friction forces and rate at which the flange wears out are also reduced.

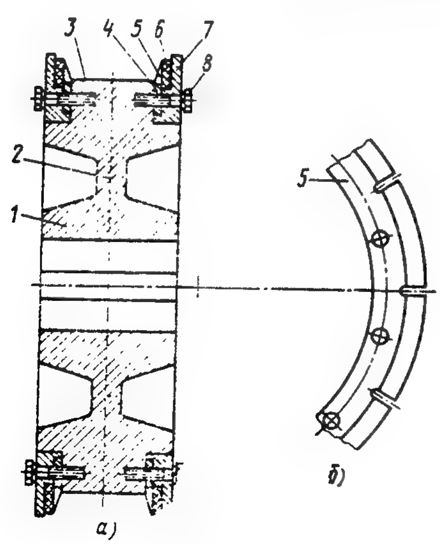

Figure 1

Using wheels with elastic flanges makes it possible, first, to slow down the wear of the flanges and increase the operating times between repairs of the wheels; second, it makes repairing the wheels much easier since the flange packets may be made of two half-rings that are detachable in the diametral plane, which makes it possible to replace them without disassembling the wheel as a whole.

UDC 621.825.031.4

Pneumoelastic Expanding Clutch

907F0052K Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 34

[Article by B. P. Spruogis, Yu. I. Yurevich, and L. A. Zubavichyus, candidates of technical sciences]

[Text] A clutch (author's certificate No 1451373) for different mechanisms, instruments, and devices has been developed at the Vilnyus Construction Engineering Institute. It is intended to connect shafts while achieving a specified rotation frequency of the driven shaft.

The driving half-coupling has a hub (11) on which an air-sucking centrifugal impeller (10) is mounted. The latter is located in a hermetically sealed rim (9) with diverters (3) along which air is fed into the compartment of an expanding clutch device that is tightly shut with an elastic casing (7). A check valve serves to keep the required compressed air pressure in the compartment. The compartment with the elastic casing encompasses the rim (8) of the driven half-coupling (2), which has windows (5) on its flange.

In the static position, the rim (8) of the driven half-coupling encompasses the compartment with the elastic

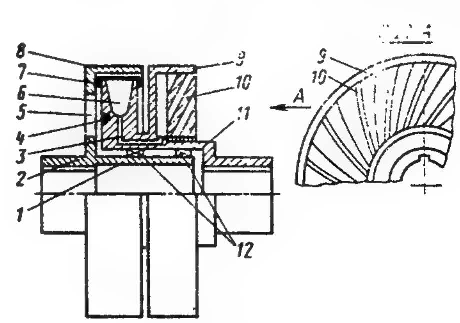

Figure 1

casing without making contact with its outer surface. The evenness of the location of the elastic casing along the entire perimeter relative to the inner surface of the rim of the driven half-coupling is possible because bearings (12) are mounted between the lobe (1) of the hub of the driven half-coupling and the lobe of the driving half-coupling. When the driving half-coupling rotates, a centrifugal impeller sucks air into the space of the hermetically sealed rim. Air is fed along the diverters into the compartment of the expanding clutch device. Under pressure, the diameter of the elastic casing increases and is pressed to the inner surface of the rim of the driven half-coupling, and this sets the latter into rotation. The moment transmitted by the clutch depends on the air pressure in the compartment. When the pressure is exceeded, air exits through the check valve into the between-rim space, which is connected to the atmosphere via windows, and cools the elastic casing, which increases the elastic element's service life.

The clutch makes it possible to connect shafts requiring increased vibration insulation of periodic perturbations in the audible frequency range. It has improved damping properties, provides smooth switching, and increases reliability and efficiency. Using a controllable check valve makes it possible to change the engagement force.

UDC 621.882.002.2:621.785.545

High-Strength Threaded Fasteners

907F0052L Moscow MASHINOSTROITEL in Russian No 9, Sep 89 pp 34-35

[Article by V. A. Pavlov, candidate of technical sciences]

[Text] At the present time the majority of threaded products (bolts, studs, nuts) are not subjected to final heat treatment (hardening) owing to thread defects that are produced during the hardening process. Machinery operation shows that the reliability of threaded products manufactured from preliminarily heat treated steel with hardening during the cold deformation process is insufficient.

In the automotive industry critically heavily loaded threaded products (bolts of connecting rod caps, motor stud bolts, and U-bolt nuts) are subject to nitrocementation and cyaniding. These processes are very lengthy and do not permit full realization of the strength characteristics of hardened alloy steels.

Induction and bulk hardening are used for bolts and studs at plants involved in the production of construction and road machinery. Additional machining of the thread is needed after this. Bulk hardening also results in large losses of threaded products owing to scorching of the vertices of the working profile.

A method for continuous thermomechanical treatment of threaded products (author's certificate Nos 1311875, 1440592, and 1449214) has been developed and tested.

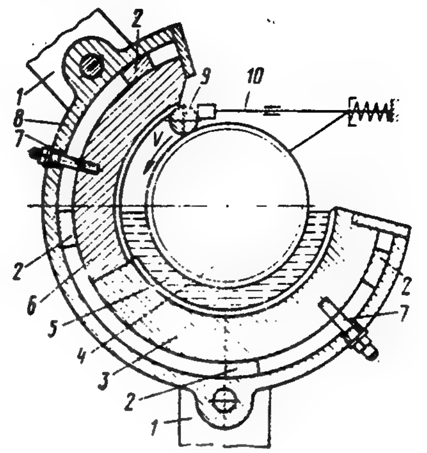

Figure 1

As an example we will take the manufacture of a hardened bolt on a planetary threading machine. A threading roller (4) with a rotation drive, a threading segment made of deforming (6) and calibrating (3) parts, guides (8), a bin with a pusher (10) for the automatic bolt-loading mechanism, and an induction heater work-coil that stands in front of the machining zone are located on the machine tool's bed (1). The drive that rotates the threading roller, the bin with the automatic blank-feeding mechanism, and the induction heater work-coil are not shown.

The automatic blank-feeding mechanism orients and transfers a bolt blank (9) from the bin through an induction heater work-coil to the blank-receiving zone. Upon heating in the induction heater work-coil to an austenitic state, the bolt blank (owing to the automatic loading mechanism's pusher and the rotating roller) is pulled into the gap between the roller and the deforming part of the segment. The roller moves the bolt blank with the velocity v relative to the deforming part of the segment (in the air medium), thus forming the thread profile. The blank, which continues to move with the velocity v, enters the quenching bath (5). Austenitic-martensitic transformations occur in the blank's structure and result in a reduction in the bolt's diameter.

The roller and calibrating portion of the segment compensate for shrinkage and calibrate the thread, for which the respective dimensions are pre-established between the roller and segment by using regulating wedges (2) and stop pins (7). The hardened and calibrated bolt leave the machining zone and roll into the drawer for finished products.

The method of continuous thermomechanical treatment was tested during the manufacture of M10 studs from 40Cr steel at the Bryansk Road Machinery Plant imeni the 50th Anniversary of the October Revolution. As a result of the treatment of three batches of stud bolts, an M10 8g threaded profile with a hardness of 52-56 HRC and a roughness Ra = 1.5-2.5 μm was produced. The method of continuous thermomechanical treatment was

used to manufacture a batch of M10 hardened nuts to perform break testing on these studs. The tests showed that the studs that underwent low-temperature tempering break under a load of 9,300 to 9,500 kgf, whereas for thermally improved and cut studs it does not exceed 4,000 kgf.

UDC 621.922.6.002.5

Device To Manufacture Flexible Abrasive Disks

907F0052M Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 35

[Article by Yu. V. Petrakov, candidate of technical sciences, and G. I. Dostovalov]

[Text] The abrasive tool is a polymer base of polyethylene terephthalate film 50 to 70 μm thick onto which an abrasive layer 10 to 25 μm thick has been applied. The layer consists of abrasive or diamond grains that are evenly distributed in a binder polymer.

An automated device (author's certificate No 1458189) to manufacture abrasive disks 200 mm in diameter from this type of strip has been developed and manufactured at Kiev Polytechnic Institute imeni the 50th Anniversary of the Great October Socialist Revolution. The device makes it possible to manufacture an abrasive strip of great length.

A feed coil (7), subassembly (6) to apply a regular microrelief onto the base, a subassembly (5) to apply an abrasive suspension, a drying chamber (4), a control panel (2), a subassembly (8) to cut out disks, and a receiving coil (10) are mounted on the bed (1).

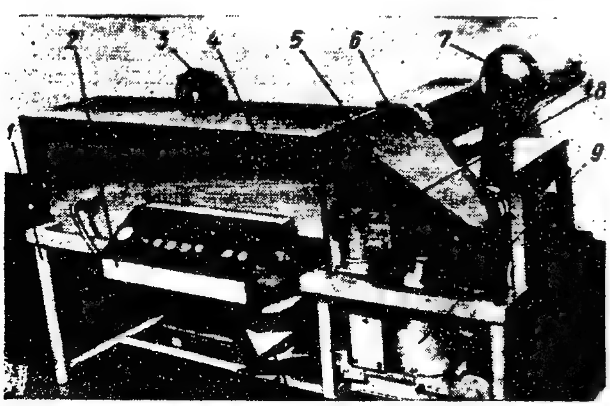

Figure 1

The subassembly to apply a regular microrelief onto the base contains a rotating spindle on which a tool made of nonwoven abrasive fiber has been mounted. Besides rotating, the tool moves in an axial direction. Such tool movements result in the formation of a large number of intersecting sinusoidal scratches on the base.

The subassembly for applying the abrasive suspension consists of fillers that can move vertically relative to the base. Mounted in the drying chamber are thermal radiation elements and a large-diameter heated metal drum. the working layer is finally dried and polymerized on the drum's outer heated surface. The drum is the drive shaft of the strip-drawing track and is set into rotation (with a controlled velocity) by a direct current motor (3).

The subassembly for cutting out disks contains a die and a punch with a cutting edge that has a complex shape and that is set into motion by an electric motor. A storage unit (11) has been introduced to ensure joint operation of the continuously acting tape-drawing track and periodically operating cutting device.

The device operates automatically and in adjustment modes. During operation in the automatic mode, abrasive disks are cut out of the abrasive strip; during operation in the adjustment mode the cutting device is switched off, and it becomes possible to manufacture an abrasive strip with a great length.

The base and feed coil pass through the subassembly applying the microrelief, which increases the adhesion of the working layer to the base. Next, an abrasive suspension that is first dried and then polymerized on the heated drum's surface is applied to the base. From the drum, the strip enters the storage unit. To achieve a specified strip length, a sensor that connects the receiving coil motor is activated, and the strip begins to enter the cutting device. The cutting process begins upon an instruction from a photosensor when the luminous flux is covered by the abrasive strip, which is less transparent than the basic strip. The receiving coil's motor is then switched off. The cycle is completed.

The device makes it possible to produce abrasive disks 200 mm in diameter with a grain size of 0.5 to 40 μm and a variation in the thickness of the abrasive layer of plus or minus 3 μm and an abrasive strip 220 to 250 mm wide and up to 300 m long.

The device has a capacity of 3 to 5 disks per minute. Its overall dimensions are 2,500 x 1,200 x 1,300 mm. It has a mass of 220 kg.

Using flexible disks in the operation of finishing the working surface of ZD24.080 Sendust magnetic heads made it possible to stop buying imported tools and to obtain a yearly economic effect of more than 20,000 rubles.

UDC 621.825.7.001.4

Test Stand

907F0052N Moscow MASHINOSTROITEL in Russian No 9, Sep 89 p 36

[Article by Yu. M. Guzenko and M. S. Kovalev, candidate of technical sciences]

[Text] The stand (author's certificate No 1106786) may be used to test elastic clutches for their load-bearing and damping capacity, torsional rigidity, the linearity of their characteristic, their wear resistance, energy loss, heating, and other parameters characterizing their operation. It contains a mechanism to load the clutch (2) undergoing testing with a constant torque T_1 and a mechanism to load it with a variable torque T_2 that is in the form of a crank-connecting rod mechanism (14) that is set into motion by a DC electric motor (12) with a controllable rotation frequency ω. The mechanism to load the clutch being tested with a constant torque T_1 is in the form of two worm reduction gears (5) and (9), which are interconnected through the shafts (6) and (15) of worm gear wheels (1) and (4) through the clutch being tested, with the reduction gear (5) being connected with the crank-connecting rod mechanism (14) by the shaft (13) of the worm (11) and the reduction gear (9) being connected with a handle (17) by the shaft (16) of the worm (10).

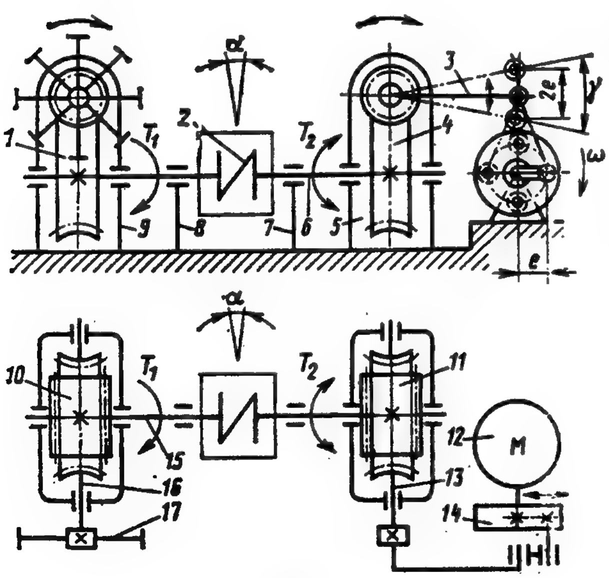

Figure 1

The shafts (6) and (15), which are located along both axes of the clutch being tested, are torsional with strain gauge transducers glued onto them that are connected to electronic testing equipment (not shown in the figure). The shafts (6) and (15) are damped by the torsional sections; additional supports (7) and (8) are therefore connected with the stand's base.

When the shaft (16) of the worm reduction gear (9) is turned by hand, the moment is transmitted to the clutch being tested. The latter transmits the torque T_1 to the shaft (6) of the worm reduction gear (5), as a result of which further transmission of the force flow of the load on the clutch being tested is curtailed by the constant torque T_1 since the worm pair in this case is self-stopping.

Thus, by turning a handle, it is possible to control (over a wide range) and establish the required magnitude of the constant torque T_1 loading the clutch undergoing testing. The applied torque R_1 is monitored and measured with the help of strain gauge transducers, in accordance with whose readings the damping capacity of the clutch being tested is determined along with its torsional rigidity, the linearity of its characteristics, its torsion angle, and other parameters.

A DC electric motor with a controllable rotation frequency that is connected via a crank-connecting rod mechanism to the shaft (13) of the reduction gear's (5) worm loads the clutch being tested with a variable torque T_2, which makes it possible to conduct dynamic tests (by using strain gauge transducers) to determine their load-bearing and damping capacity, fatigue strength, durability, wear resistance, energy loss, heating, and other parameters. By changing the electric motor's rotation frequency it is possible to control the frequency of the fluctuations of the variable torque T_2 that is applied to the clutch undergoing testing (which is equal in magnitude to the electric motor's rotation frequency). By changing the magnitude of the eccentricity e in the crank-connecting rod mechanism, it is possible to control the magnitude of the fluctuations α of the variable torque T_2 with a high precision since the crank-connecting rod mechanism is kinematically linked with the clutch undergoing testing through a worm reduction gear (5) and the amplitude of the fluctuations of the variable torque T_2 in the clutch will be u times less than the amplitude of the fluctuations of the variable torque on the shaft (13), i.e., $\alpha = \gamma/u$, where γ is the amplitude of the fluctuations of the variable torque on the shaft (13) connected with the connecting rod (3) and u is the gear ratio of the worm reduction gear (5).

When necessary, it is possible to disconnect the worm (10) from the worm gear wheel (1) and apply a variable torque T_2 (inertial torque from the massive flywheel, which in the given design is the worm gear wheel (1) of the reduction gear) to the clutch, which makes it possible to test the clutch for durability, damping capacity, and other dynamic characteristics. This possibility gives the test stand universality since one and the same structural elements of worm reduction gears may create different loads on the clutch.

The stand makes it possible to increase the precision of simulating the operating modes of elastic clutches thanks to the presence of two worm reduction gears, one of which is located between the clutch being tested and the crank-connecting rod mechanism. It also plays the role of a power amplifier during dynamic loading.

Abstracts Appearing in 'Bulletin of Higher Educational Institutions: Machine Building'

907F0058 Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 8, Aug 89

[Abstracts appearing in "Bulletin of Higher Educational Institutions: Machine Building," August 89]

[Text]

UDC 519.6:539.3

Stability of Finite Element Solution of Problems of Mechanics of Composite Structures. E. I. Grigolyuk, doctor of technical sciences and professor, P. Ya. Nosatenko, candidate of physical and mathematical sciences, and M. N. Omelchenko, engineer, pp 3-6

This article examines the problem of the stability of the finite element solution of an elasticity theory problem for composite materials. It is established that the most stable model is that consisting of finite elements extended in the direction of the maximum rigidity, with the ratio between the lengths of the sides depending on the ratios between the elastic constants. The results of numerical investigation of the dependence of the maximum eigenvalue of the rigidity matrix on the form of the finite element are presented for an axiosymmetrical elasticity theory problem for an anisotropic body. Figures 2, references 9: Russian 8, Western 1.

UDC 539.4

Nonsteady Creep of Thick-Walled Pipe of Material With Different Characteristics During Extension and Compression. V. Ye. Voronin, graduate student, and A. A. Shirshov, candidate of technical sciences and docent, pp 7-9

This article presents the solution to a problem of the nonsteady creep of a thick-walled pipe that is loaded with internal pressure, that is made of a nonlinear viscous material, and whose creep characteristics depend on its type of stressed state. A calculation algorithm is presented. Stress patterns at different moments in time are presented along with graphs of the change in stresses over time. Figures 2, references 6 (Russian).

UDC 539.43:621.01

Method of Cycle-by-Cycle Summation of Damages During Cyclic Loadings. M. V. Fomin, candidate of technical sciences and docent, pp 10-14

This article examines a method of summing the damages in a region of multicycle fatigue. An energy failure criterion is placed at its foundation. The asymmetry of the loading cycles is considered. Figures 3, references 5 (Russian).

UDC 621.787:539.319

Effect of Residual Stresses on Endurance Threshold During Asymmetrical Cycle in Case of Extension-Compression. V. F. Pavlov, doctor of technical sciences and docent, V. A. Kirpichev, engineer, B. V. Minin, assistant, and V. I. Lapin, engineer, pp 14-18

This article proposes a method of plotting a diagram of the threshold amplitudes of the cycle of a hardened component with a stress concentrator based on residual stresses in the dangerous cross section. Figures 2, table 1, references 7: Russian 6, Western 1.

UDC 539.3

Optimization of Round Cylindrical Shell With Piecewise-Constant Thickness and Elastically Constrained Edges. Ye. A. Prokopyev, candidate of technical sciences and assistant, pp 18-21

The problem of the maximum external axiosymmetrical pressure acting on a round cylindrical shell with elastically constrained edges is formulated and solved on the basis of a semimomentless theory. The shell's mass is constant. Bilateral constraints are applied onto the shell's thickness. The specified problem is solved by the possible directions method using the gradient of the functional being optimized. Graphs of the optimal shell thicknesses at different values of the longitudinal rigidity of the elastic constraint on the edges are presented. Figures 3, table 1, references 5 (Russian).

UDC 539.4

Stability and Growth of Round Stratifications in Layered Components of Structures. L. A. Bokhoyeva, graduate student, pp 21-23

This article examines the effect of defects of the type of round stratifications propagated onto the design components of layered anisotropic materials. Figures 3, references 3 (Russian).

UDC 539.3:624.074.001

Calculating Lateral Compliance of Pneumatic Rubberized Cord Shock Absorber With Approximate Allowance for Extensibility of Cord Filaments. V. L. Biderman, doctor of technical sciences and professor, G. V. Martyanova, candidate of technical sciences and docent, and F. D. Sorokin, assistant, pp 24-27

This article examines a method of allowing for the extensibility of the filaments of a reticular shell of revolution during the effect of a lateral load. It is established that, for shells manufactured from polyamide filaments, the compliance is determined primarily by the extensibility of the filaments. Figures 3, references 3 (Russian).

UDC 621.833.1

Compliance of Gear Teeth of Novikov Cylindrical Gearing. G. P. Akhyrets, candidate of technical sciences

and docent, V. I. Korotkin, candidate of technical sciences and professor, A. V. Pavlenko, candidate of technical sciences and professor, and V. Ye. Fomenko, engineer, pp 27-31

A method is given for determining the form of the analytical dependence of the magnitude of the total displacement of a tooth from the engagement parameters. The research was conducted for pairs of Novikov gearings with initial contours in accordance with GOST 15023-76, RGU-5 over wide ranges of active loads and geometric gearing parameters by using the method of finite integral equations. The discrepancy between the displacements calculated by using the formula derived and the results of the experiment does not exceed 9 percent. The proposed engineering formula makes it possible to avoid resorting to cumbersome applications packages when investigating the compliance of a gear tooth as a function of the loading and engagement parameters. Figures 2, references 6 (Russian).

UDC 539.3

Rocking of Cylinder Lined With Incompressible Elastic Material. V. V. Mishin, professor, and A. A. Serdyuk, engineer, pp 31-36

Equations of the motion of an incompressible elastic medium in a complex region with boundary conditions describing contact boundary friction based on Coulomb's law are solved to establish the characteristics of the steady rocking of a lined cylinder. The motion and constraint equations repeat Navier-Stokes equations. The boundary conditions are satisfied by the weighted discrepancy method. The calculation results are in satisfactory agreement with the data from the experiments. Figures 3, references 5: Russian 4, Western 1.

UDC 621.722:621.893

Investigation of Wear Dynamics of Separators of Self-Lubricating Bearings. K. G. Gan, candidate of technical sciences and docent, and L. M. Zaitov, engineer, pp 36-41

This article examines the dynamics of the wear of a self-lubricating separator that has been manufactured from filled fluoroplast and that is mounted in a high-speed radial thrust ball bearing. The phenomena accompanying wear are also analyzed. It is shown that the makeup of the self-lubricating composite and the processes of film formation on the balls and rings affect the bearing's life. Figures 3, references 5.

UDC 531.381

Systems Approach to Metric Analysis of Open Kinematic Chains. A. A. Golovin, candidate of technical sciences and docent, and Ye. V. Kaplinskiy, graduate student, pp 41-46

This article presents a comprehensive metric analysis of the positions of all of the links of an open kinematic chain. A modular-matrix form of recording and subsequent recurrent formula ensure minimal analytical preparation of the problem. Figures 3, references 2 (Russian).

UDC 621.833.001.5

Theory of Gearing With Two Degrees of Freedom. Dun Syue-Chzhu, professor, pp 46-51

This article examines the results of a theoretical investigation of toothed engagements with two degrees of freedom. A detailed analysis of the termination lines of the surfaces of the teeth is given. Simple formulas for calculating the normal curvatures and adjusted geodesic torsion are derived. References 5 (Russian).

UDC 621.833.6

Determination of Distribution Densities of Values of Coefficients Allowing for Load Distribution in Gear Engagements of Planet Gearing. K. G. Gopgots, candidate of technical sciences and senior instructor, and L. B. Chernov, doctor of technical sciences and professor, pp 51-55

This article examines the determination of the probability distribution functions of the values of the coefficients allowing for the load distribution along the width of gear rims and the unevenness of the loading of the satellites of a type 2K-N planet gear with nonsmooth central gears and that is loaded with a torque and a radial force. The resultant dependencies may be used when calculating gears' durability. Figure 1, references 7 (Russian).

UDC 532.546

Filtration in Porous Wedge in Presence of Local Zones. V. M. Polyayev, doctor of technical sciences and professor, V. V. Faleyev, doctor of technical sciences, and I. G. Drozdov, engineer, pp 56-60

The exact solution is derived of a nonlinear problem about the filtration of a newtonian liquid in a wedgelike region with a selection along the symmetry axis. The physical pattern of the flow of coolant in a direction from the constant pressure line to the local runoffs along the impermeable bounds of the porous space is plotted. Figures 2, references 5 (Russian).

UDC 532.546

Problem of Numerical Solution of Problem of Laminar Flow of Liquid in Nonround Pipes. B. Ya. Benderskiy, candidate of technical sciences and docent, and R. Kh. Mullakhmetov, candidate of technical sciences and docent, pp 60-62

Data are obtained on the values of the pressure loss coefficient A, Coriolis coefficient α, ratio of the maximum local velocity to the average velocity $\gamma = u_* v$ in the interval $\varphi = 90°$ to $180°$, and the Boussinesq coefficient β in the interval $\varphi = 5°$ to $180°$ during a trial of a numerical method of solving a Poisson equation. Table 1, references 5 (Russian).

UDC 621.67.001.5

Using Double-Row Blade Cascade in Impeller of High-Speed Centrifugal Pump. O. V. Baybakov, doctor of technical sciences and professor (deceased), and A. Yu. Sinenko, candidate of technical sciences, pp 62-64

This article presents the results of an experimental investigation of a double-row blade cascade of a centrifugal pump's impeller. The effect of the diameter of the inlet to the second row, the size of the clearance between the rows, and the amount of overlapping of the rows of blades on the pump's pressure characteristics and k_{eff} is shown. Figures 3, references 4 (Russian).

UDC 621.029

Variation Problem of Mechanics of Motor-Damping Base Interaction. A. V. Miroshnichenko, candidate of technical sciences, pp 65-69

The lines of contact between a propeller and the medium in the case of different representations of the reaction are determined for the effect providing the extreme for the functional being plotted. Figures 2.

UDC 622.627.2

Mathematical Model of Deformation of Medium in Case of Multiply Applied Quasistatic Loads. T. N. Bekenov, candidate of technical sciences, pp 69-72

The law governing the formation of repeated loads by a car onto the soil of a heading is established in accordance with the law of arithmetic progression on the basis of the change in time for which the car is in contact with the medium. A mathematical model is developed that describes the plastic deformability of a medium with linear hardening owing to the effect of repeated short-term loads. Figures 2, references 5 (Russian).

UDC 629.113-585.2

Features of k_{eff} of Double-Sided Gearings With Variable-Speed Drive. N. I. Narbut, engineer, pp 72-75

Efficiency curves of two-sided gearings with external branching of the force flow are derived and analyzed for a simplified characteristic of the k_{eff} of a mechanical infinitely variable transmission equal to 0.75. Figures 2, table 1, references 3 (Russian).

UDC 539.3

Failure of Crystallizing Metal Alloys. V.L. Danilov, doctor of technical sciences and docent, and S. V. Zarubin, candidate of technical sciences and assistant, pp 76-80

This article proposes a kinematic theory of the brittle destruction of metals and alloys in the presence of a liquid phase along the grain boundaries with an allowance for the possibility of healing the damage. The experimental data are compared with the theoretical results obtained. Figures 3, references 10: Russian 8, Western 2.

UDC 621.771

Analysis of Interaction of Cushions of Top Support Beam With Pressure Screws in NShS 2500 Finishing Cage. V. I. Borisov, candidate of technical sciences and docent, O. N. Prokopenya, assistant, and Ye. R. Sysoyev, engineer, pp 80-83

This article discusses the results of an analysis of the loads in the supports of the upper backup roll of a 2500 continuous strip mill. Figures 2, references 2 (Russian).

UDC 621.771

Determining Contact Stresses During Longitudinal Rolling of Pipes. G. S. Nikitin, doctor of technical sciences and professor, and I. A. Khokalo, engineer, pp 84-87

This article examines the determination of the forces of the rolling of pipes and uses theoretical and experimental developments as a basis for deriving a new dependence that considers the effect of the nonreduced portions of the pipe in the deformation focus. Figures 2, references 3 (Russian).

UDC 621. 961.01.001.5

Build-up of Deformation and Failure of Blank During Slitting. V. A. Timoshchenko, candidate of technical sciences and docent, pp 87-90

This article discusses the results of research on the deformation buildup in the process of cutting a band and the law governing blank failure. Two failure mechanisms in the separation process are established, and these cause the different roughnesses of the cut surface. Figures 2, references 3 (Russian).

UDC 621.983.3.001.1

Investigation of Focus of Plastic Deformation When Sheet Material Is Cut Out. N. A. Akastelova, engineer, and S. I. Vdovin, doctor of technical sciences, pp 90-92

This article investigates the effect of bridging piece width on the development of plastic zones in a material when the cutting edges of a tool are introduced into it, and the critical value of the bridging piece is found. Figures 2.

UDC 620.10

Estimating Healability of Defects During Nonmonotonic Deformation of Noncompact Materials. N. A. Shestakov, candidate of technical sciences and docent, pp 92-98

A phenomenological approach is proposed for forecasting phenomena related to the healability of the defect structure of powder and chip materials in hot plastic deformation processes. A linear tensor model of the aging of defects

by the coalescence of fragments is the foundation of the approach. Figure 1, references 4 (Russian).

UDC 519.67:621.979

Designing Articulated Bed Frame of Heavy Press for Stamping Elastic Cushion. A. A. Fedorov, assistant, pp 98-103

This article examines the design of ram presses for thin-sheet stamping with an elastic cushion. An algorithm is set forth for the first stage of the solution, when the boundary elements method is used to solve the problems of crossbeam-arch and arch-column contact and the problem of the interaction of the arch with the winding pack. Since each of the problems may only be solved by the iteration method, a single iteration algorithm containing only those components that are directly involved in the iteration process is constructed. Diagrams of the forces of the interaction of the arch and pack of a press with a force of 400 MN are presented. Figures 3, references 9 (Russian).

UDC 658.512.011.56:621.9-529

Determining Sequence of Machining Operations on NC Machine Tools Using Model of Production Environment. R. B. Dilanyan, candidate of technical sciences and docent, and A. G. Berdyshevskiy, graduate student, pp 103-107

This article examines the possibility of using mathematical models derived in the technological design and grouping stage to model the processes of retooling NC equipment in order to determine the quality estimates that are the source data when optimizing the purpose of machining production operations and scheduling a production system's operation. Implementing the specified approach simplifies the integration of technological design and planning systems. Figures 2, form 1, references 4 (Russian).

UDC 658:621.9.014

Analysis of Production Capabilities of Flexible Manufacturing Systems. L. S. Vorovich, candidate of physical and mathematical sciences and professor, B. I. Gordiyenko, doctor of technical sciences and professor, and M. A. Kraplin, candidate of physical and mathematical sciences and docent, pp 107-111

A mathematical model is constructed of the production process entailed in using a flexible manufacturing system to machine a set of components. An algorithm for calculating a flexible manufacturing system's capacity is developed.

The model constructed may serve as an invariant core of a wide set of new models of modern metal working. The model makes it possible to implement a production analysis of a flexible manufacturing system, optimize metal working modes using a flexible manufacturing system, and calculate the optimum equipment set when designing metal working shops.

UDC 658.52.011.56:621.9-529

Time Required to Retool Flexible Manufacturing Module With Allowance for Optimum Sequence of Machining Components. G. N. Vasilyev, candidate of technical sciences and docent, and L. M. Kopaleishvili, graduate student, pp 111-115

This article examines a model of the capacity of a flexible manufacturing module when it is used in large-series production. The concept of the productivity of machining a set with an allowance for the productivity of machining each component in the set is introduced. An algorithm is developed that makes it possible to minimize the replacement of tools (in the event of a constraint on the tool magazine's capacity) by selecting the optimum sequence of machining the components. A sample calculation based on a program implementing the given algorithm is presented. Figures 2, table 1, references 4 (Russian).

UDC 621.9.01:531.3

Estimating Precision of Approximate Method of Calculating Parametric Stability of Machine Tools. Yu. F. Kopelev, doctor of technical sciences and docent, A. R. Shenderov, candidate of technical sciences and docent, and N. N. Ostapovich, graduate student, pp 115-118

This article compares the results of calculations of the critical value of the coefficient of the excitation and frequency of major parametric resonance obtained in a first approximation of the perturbation method and those obtained by using the numerical method. It is shown that the relationships obtained by the perturbation method provide a precision that is sufficient for engineering calculations of the parametric stability of machine tools. Figures 2, references 4.

UDC 621.825

Designing Safety Devices Based on Vector Synthesis. S. G. Nagornyak, candidate of technical sciences and docent, pp 118-121

This article examines the topic of creating original devices to prevent overloads and breakdowns of metal-cutting machines and tools in transient cutting processes. The author proposes that vector synthesis be used to create such devices. An array of simple mechanisms controlling transient cutting processes is created as a result of the mismatch of the linear displacement vectors, which may be coaxial, parallel, or sloped. All of the mechanisms created on the basis of vector synthesis and presented in the table included in this article are protected by inventor's certificates. Table 1, references 11 (Russian).

UDC 620.175.22(088.8)

Increasing Precision of Fine Movement Mechanism of Metal-Cutting Machine Based on Design Control of Elastic Sequence. G. S. Ivasyshin, candidate of technical sciences and docent, pp 121-125

This article gives a qualitative assessment of the effect of an elastic aftereffect on the precision of positioning a grinding wheel head on an elastic suspension. The analytical dependence of the precision of positioning an elastic drive on the following is derived: the elastic deflection and elastic aftereffect of the flat springs, the fact that the screw journal and the stop approximate a friction pair, and the coordinates of the grinding wheel and flat springs.

Recommendations regarding modifying the calibration of the limb of the fine movement mechanism are presented. Figure 1, references 8 (Russian).

UDC 628.517

Investigation of Prognostic Models of Machines' Noise Characteristics. I. N. Zapletnikov, candidate of technical sciences and docent, and T. I. Kratkova, engineer, pp 126-129

The statistical parameters of models plotted by the dynamic regression method on a YeS 1022 computer are analyzed by way of the example of prognostic models of the noise characteristics of an MP-800 machine. Practical recommendations regarding using these models during the forecasting process are presented. Tables 4, references 2 (Russian).

UDC 621.9.048.7

Increasing Wear Resistance of Tool Materials by Modifying Low-Energy Ion Flux. V. S. Kamalov, doctor of technical sciences and professor, I. V. Khodyrev, graduate student, and A. M. Kotov, graduate student, pp 129-133

The results of theoretical and experimental research are used to demonstrate the feasibility of using low-energy plasma ions of a glow discharge to modify tool materials so as to increase their durability.

The microstructure and physicomechanical properties of materials modified by the specified ions are investigated, and the proposed mechanism of increasing the durability of these materials is set forth. Figures 3, references 8 (Russian).

UDC 621.9.042

Calculating Shear Angle During Chip Formation. N. N. Ogrkov, candidate of technical sciences, pp 134-138

The slip line method is used to solve the problem of determining the shear angle during chip formation. A formula is derived that makes it possible to calculate the values of the shear angle as a function of the properties of the material being machined, rake, cutting modes, type of chip being formed, and friction conditions along the anterior tool surface. Figures 3, references 5 (Russian).

UDC 621.787.4

Reducing Effect of Heat Treatment Defects on Quality of Components by Means of Surface Plastic Deformation. P. S. Chistoserdov, candidate of technical sciences and professor, and R. N. Shaduro, candidate of technical sciences and docent, pp 138-141

This article shows the feasibility of using mandrel burnishing of slit openings in different stages of manufacturing components, which makes it possible to significantly reduce the effect of heat treatment defects on the precision of the dimensions, shape, and quality of their surfaces. Figures 2, references 2 (Russian).

UDC 601.91.02

Residual Stress of Surface Layer During Rotation Honing. A. M. Gafarov, candidate of technical sciences and docent, and G. M. Babayev, engineer, pp 141-145

Experimental data are used as the basis for establishing the effect of reciprocating motion, peripheral velocity, specific pressure, diamond bar grain size, and machining time on the magnitude of the residual stresses during rotary honing. The research results show that a residual stress that is propagated to a depth from 0.005 to 0.35 mm arises in the surface layer of workpieces during honing. The magnitude of the residual stresses during honing may be controlled over a rather wide range by chaining the key production parameters of the machining. Figures 3, references 2.

UDC 657.471

Selecting Generalized Efficiency Indicator in Case of Technical and Economic Assessment of Systems of Cryogenic Support of Superconducting Devices. I. P. Vishnev, candidate of technical sciences, S. I. Balakleyskiy, graduate student, and Yu. N. Mymrin, pp 146-150

This article discusses a method for making a comparative evaluation of the efficiency of the functioning of cryogenic support systems for superconductor devices with a cryoagent in different thermodynamic states. It is proposed that a generalized dimensionless technical and economic indicator be used in the early design stages for this purpose. Figure 1, references 5 (Russian).

UDC 621.753.5

Selection and Substantiation of Proportionality Criterion of Producing and Tool Shops. S., G. Falko, candidate of technical sciences, and S. Sh. Savadyan, engineer, pp 150-153

This article examines the matter of the need to establish optimum production proportions of producing and tool shops at machine building enterprises. The most prevalent indicators for assessing the proportionality of production structures are analyzed, and a new proportionality criterion, i.e., the standard time fund, is proposed and substantiated. References 3 (Russian).

UDC 658.012

Formation of Optimality Criterion of Parametric Series of Machines. S. M. Korenevskiy, graduate student, pp 153-156

This article proposes a classification system and order for implementing the operations entailed in selecting the optimality criterion for a parametric series of machines. Figure 1.

UDC 621.914.042-529

Automating Preparation of Geometric Information for Machining Complex Curvilinear Surfaces Under Conditions of FMS. L. M. Baldin, candidate of technical sciences and docent, and A. N. Sergeyev, engineer, pp 157-160

The modeling of a complex curvilinear surface that is subjected to machining under the conditions of a flexible manufacturing system is proposed. An algorithm is set forth for the operation of the system that makes it possible to determine the parameters of the interaction of a tool and a blank with a complex profile continuously along the machining trajectory and that makes it possible to visualize the process of designing such machining and simplify the debugging of control programs for NC equipment. Figures 3.

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